MINX Document 6
Handling Complexities in Height Retrievals

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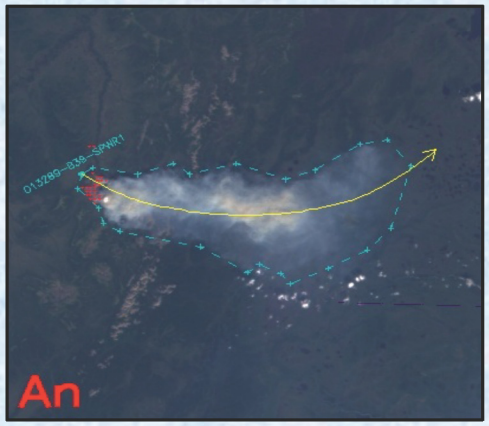
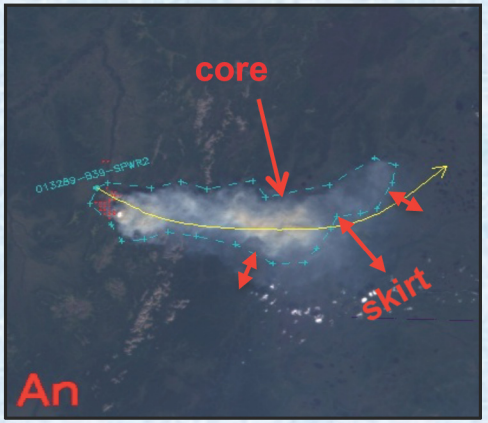
Plume Boundaries - “Core” .vs. “Skirt”

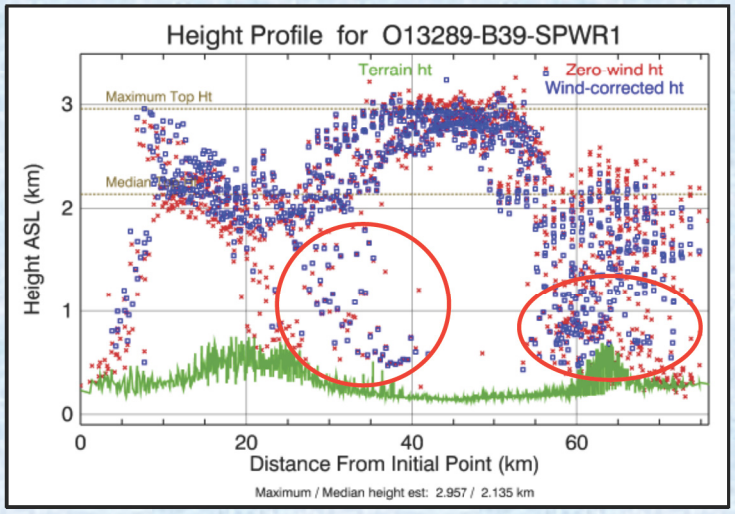
Issue: Some plumes have an optically dense core at a higher altitude than a marginal skirt of lower optical density aerosols. Digitizing the skirt together with the core biases the estimate of median plume height low.

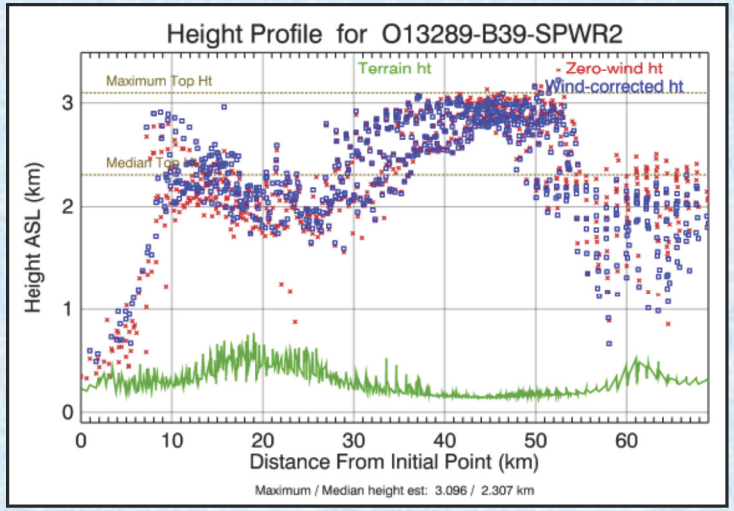


Solution: If the height profile has an excess of low retrievals and they occur on the plume margins, redigitize the plume keeping the bounding polygon closer to the core.



Alaska plume, June 2002





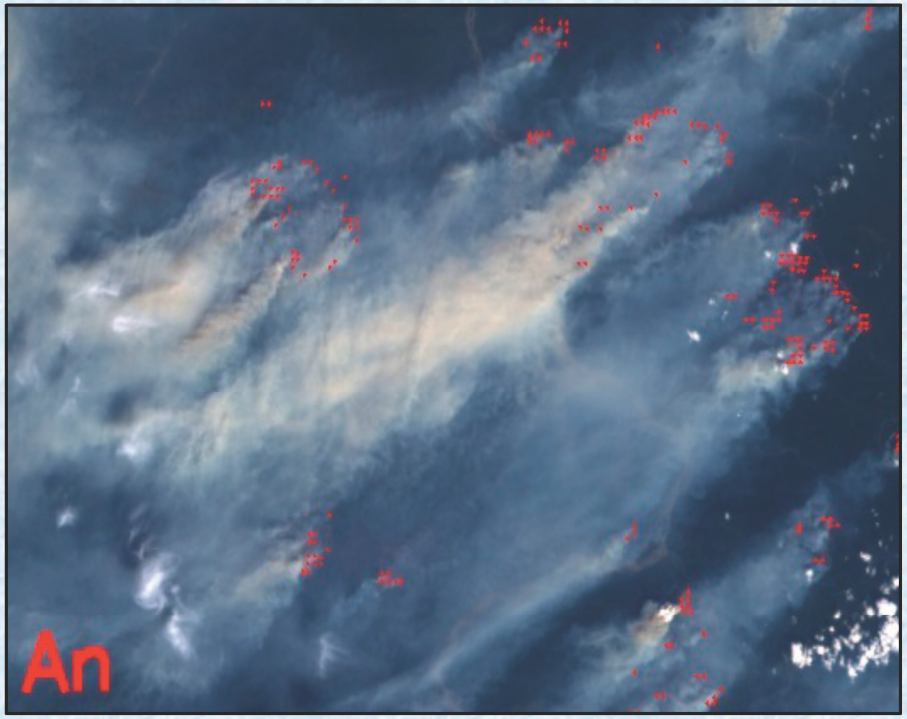
Plume Boundaries – Merging Plumes

Issue: Some dust plumes and some smoke plumes along fire fronts have broad or overlapping source regions that make it difficult to determine how to isolate individual plumes for digitizing.

Solutions:

- **Use MODIS fire pixels as a guide when available and always enclose fire pixels within the plume polygon to which you think they belong.**
- **Study the animation to infer what parts of the aerosol feature are continuous and belong to same source region.**
- **If smoke from several sources clearly merges into a single plume, digitize them as one.**

Example of complex, overlapping plumes



Alaska, 2004 - Orbit 24123

Plume Boundaries – Merging Plumes

Issue: Some dust plumes and some smoke plumes along fire fronts have broad or overlapping source regions that make it difficult to determine how to isolate individual plumes for digitizing.

Solutions:

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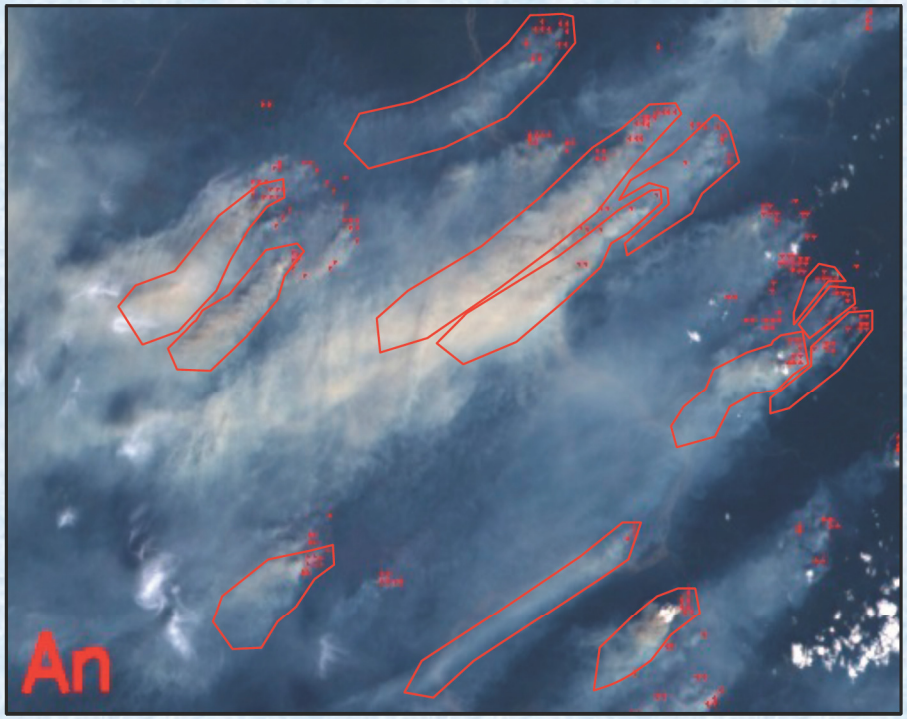
- Study animation to infer what parts of the aerosol feature are continuous and belong to same source region.
- If smoke from several sources clearly merges into a single plume, digitize them as one.

One interpretation of plume boundaries for a selection of overlapping plumes

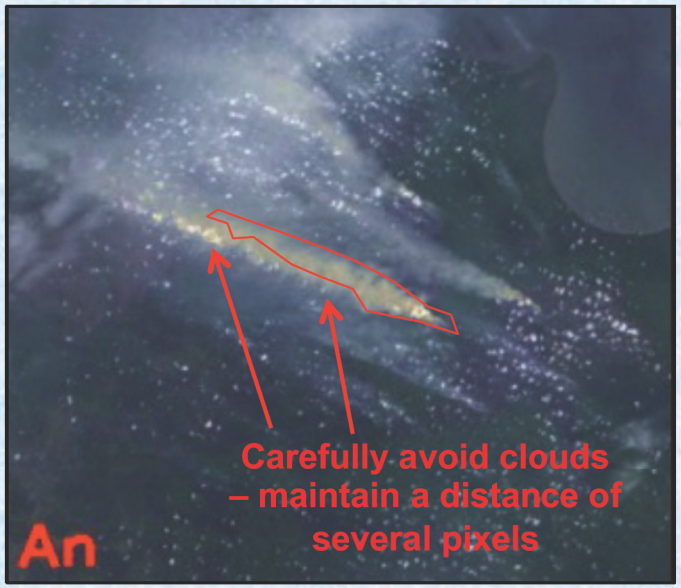


Alaska, 2004 - Orbit 24123

Plume Boundaries – Cloud Contamination

Issue: Aerosol plumes may be partially obscured by clouds which, if they are included in the digitized plume boundary, can corrupt retrieval results.

Plume boundary avoids potential cloud contamination



Borneo, 2006 - Orbit 36068

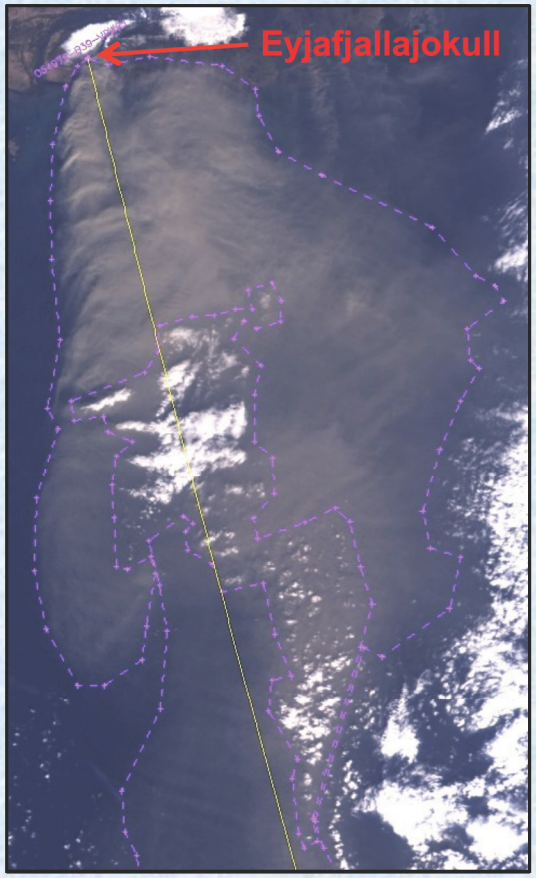
Solutions:

- **Avoid including <u>even a very small cloud</u> within or near the digitized plume boundary. To avoid contamination, a safe distance is one-half the image matcher size (about 5 pixels).**

OR

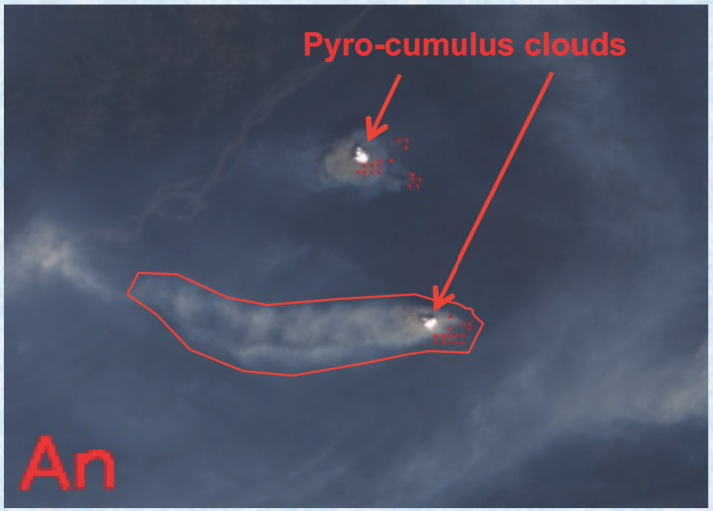
- **If the cloud(s) are higher than the aerosol and cleanly separated, set the digitizing options parameter "Max hght above sea level" to a value between their heights. Excessive <u>wind-corrected heights</u> will be filtered out.**

Avoiding clouds in Eyjafjallajokull ash plume - Iceland, April 19, 2010



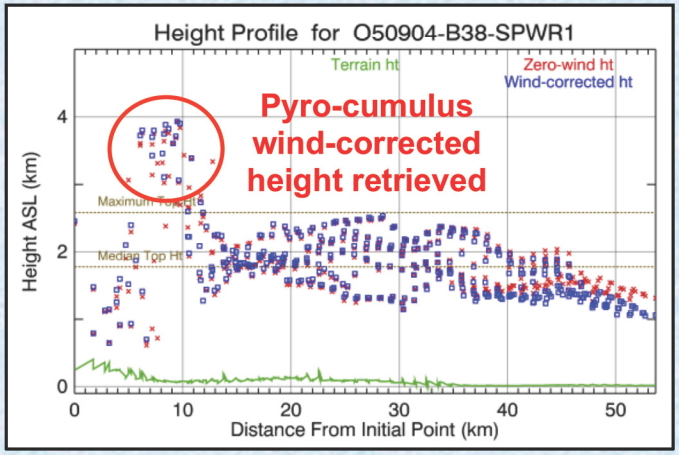
Plume Boundaries – Pyro-Cumulus Clouds

Issue: Pyro-cumulus clouds are a special case of the cloud contamination issue. To the extent they are believed to transport fire products above the boundary layer, they should be included in the digitized plume boundary. Generally they should be excluded.

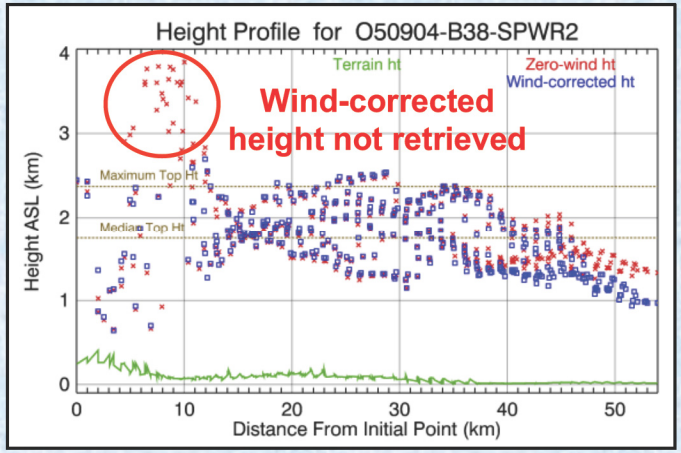


Alaska, 2009

Max height above sea level set to 5 km



Max height above sea level set to 2.8 km



Solutions:

- **Set parameter "Max hght above sea level" in "Digitizing Dialog" to a value above the smoke and below the pyro-cumulus OR**
- **Digitize around the pyro-cumulus cloud**

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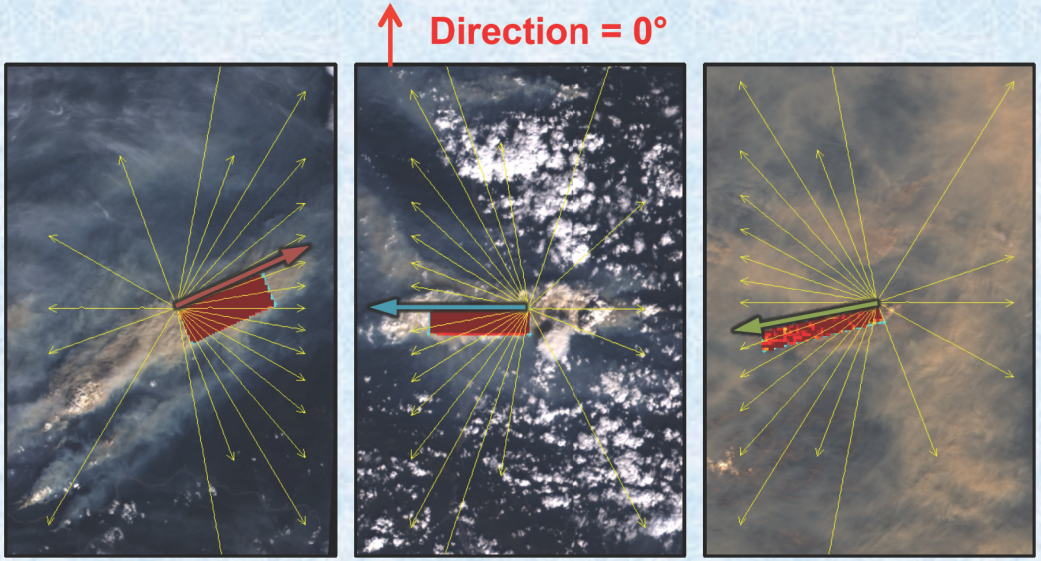
Wind-Corrected Height = f(Wind Direction)

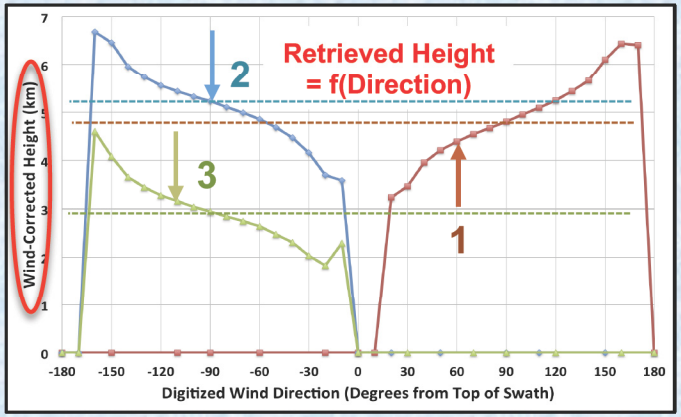
Issue: Correctly specifying the wind direction can be one of the most important and difficult tasks in plume digitizing. A poor choice can produce wind-corrected height errors of kilometers in some cases.

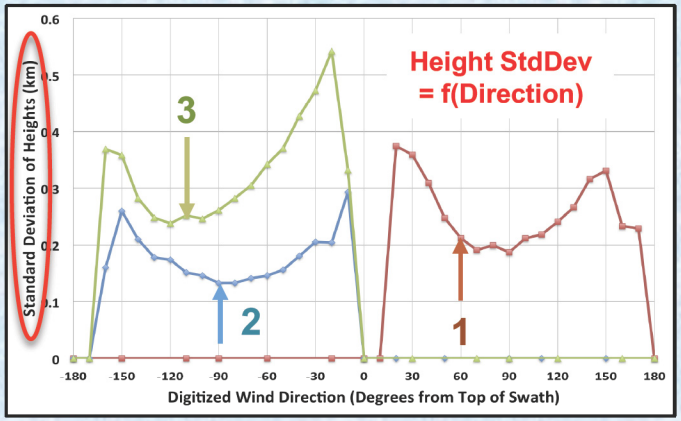


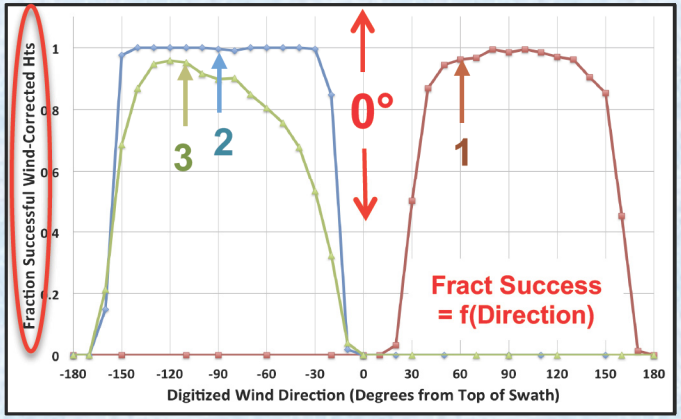
1 - Orbit 24298 2 - Orbit 24152 3 - Orbit 24123

- A patch (red) of each large, flat plume was digitized many times using different wind directions (yellow arrows)
- For each wind direction, the mean retrieved wind-corrected height, height standard deviation and fraction of attempted point retrievals that were successful were plotted

Colored arrows point to true wind direction for each orbit
Dashed horizontal lines are zero-wind heights for each orbit

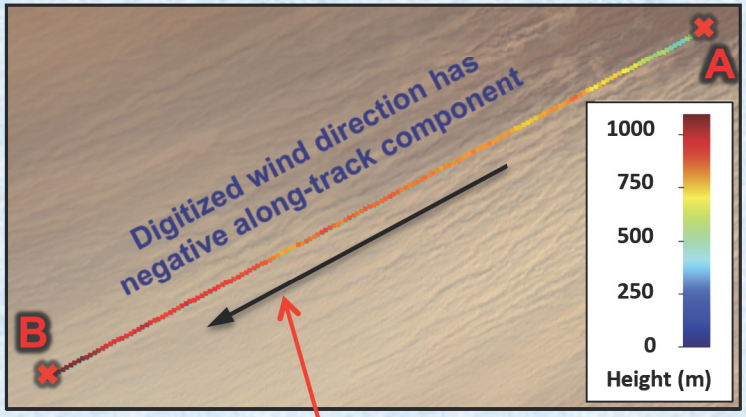


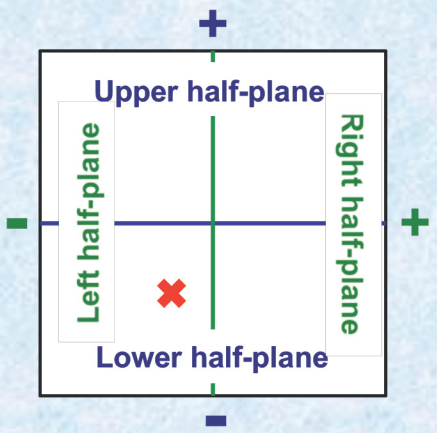




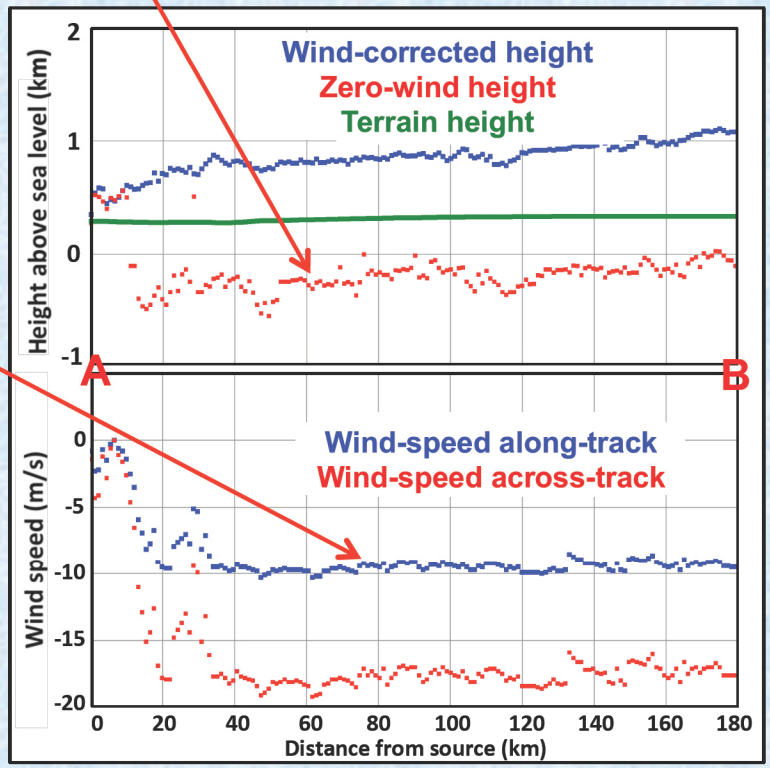
Wind Direction: Zero-Wind .vs. Wind-Corrected Heights

Large dust plume in Bodele Depression, Chad - Orbit 43484 - Feb. 20, 2008





Zero-wind heights are below the terrain and below sea level !
OK, because they're fictitious quantities

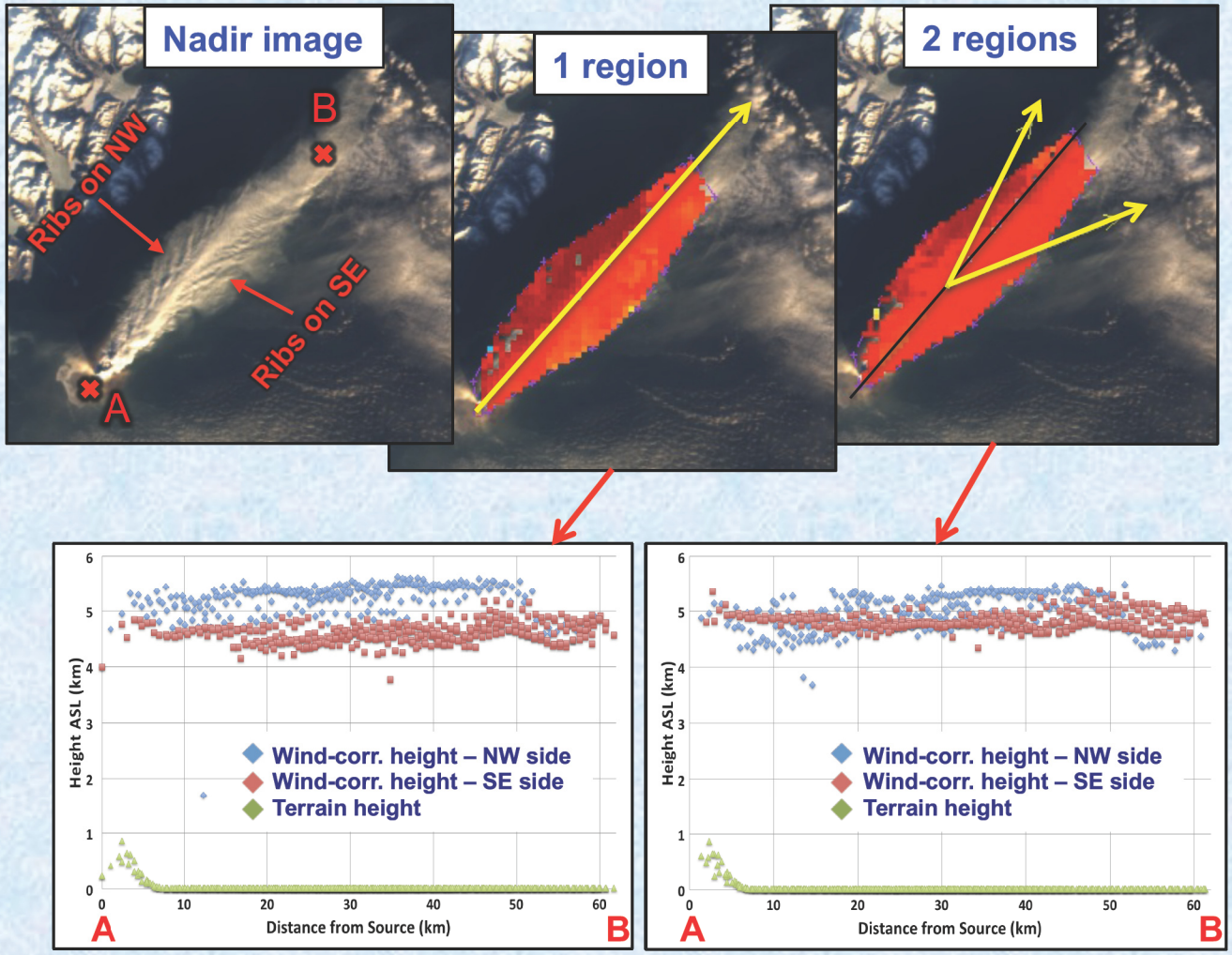


- If digitized wind direction has negative along-track component (points toward lower half-plane), then wind-corrected heights will be greater than zero-wind heights
- If digitized wind direction has positive along-track component, then wind-corrected heights will be less than zero-wind heights
- If digitized wind direction is exactly across-track, then wind-corrected heights will be equal to zero-wind heights

Wind Direction : Plume Bifurcation

- Central spine and diverging ribs suggest vortices caused by wind shear
- Digitized twice: first with 1 region and wind direction, and then with 2 regions and wind directions
- For 1 region, NW and SE sides differ in height by ~ 1 km
- For 2 regions, heights are similar and converge toward 5 km
- Supports hypothesis that ribbing is an indication of plume bifurcation w/ winds parallel to ribs

Bifurcated ash plume - Augustine volcano, Alaska - orbit 32555, Jan 30, 2006
Airline pilot reported plume with flat top at ~ 5 km



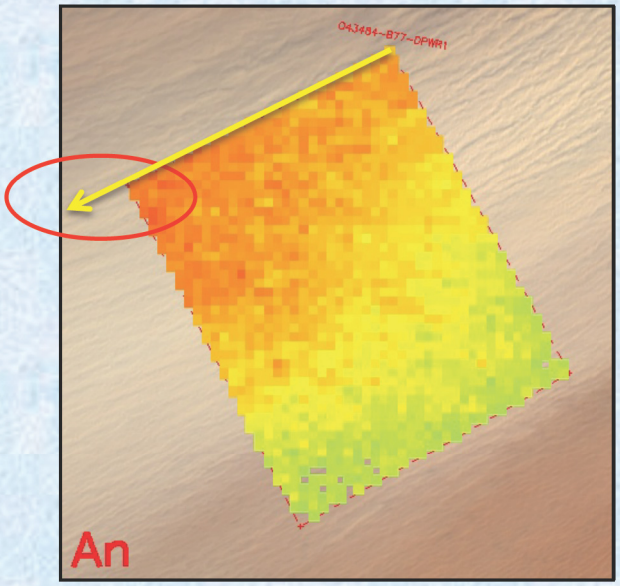
1 region and wind direction

2 regions and wind directions

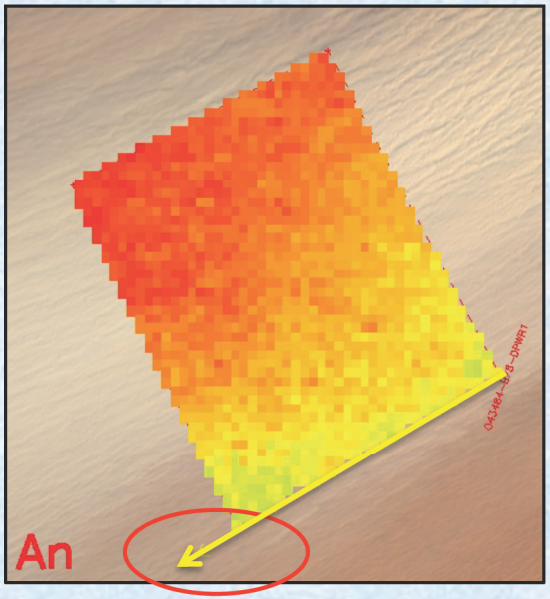
Wind Direction : Plume Divergence

Issue: Plumes that are near the ground and moving very fast are very sensitive to errors in wind direction. If the plume diverges downwind even slightly, using a single wind direction can lead to significant height errors.

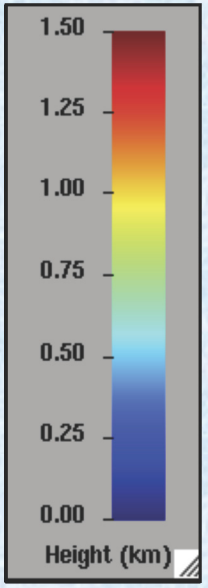
Bodele Depression dust, Chad - Orbit 43484, February 20, 2008



Using constant wind direction appropriate for NW side of plume



Using constant wind direction appropriate for SE side of plume



Wind speed > 20 m/sec

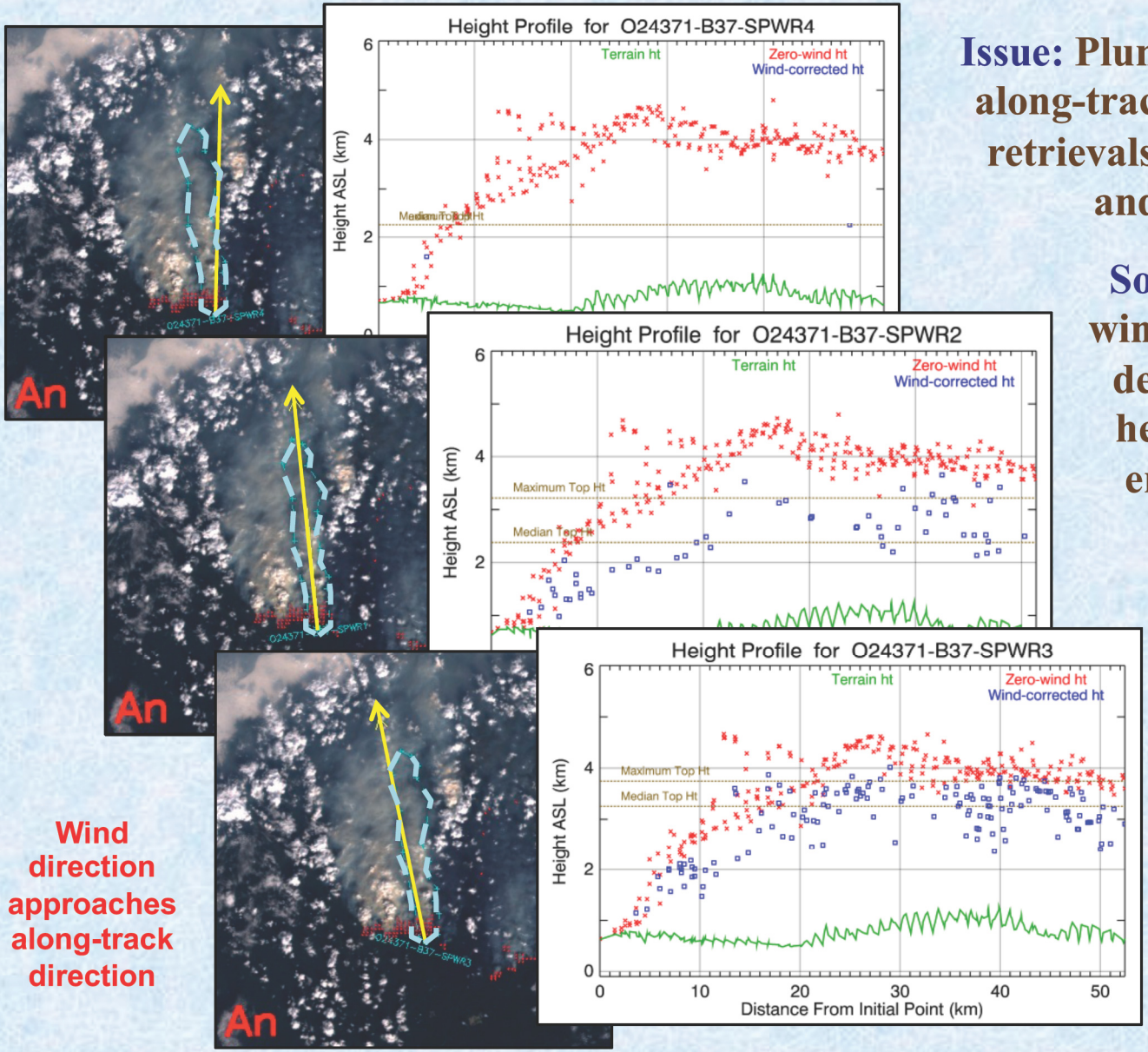
Terrain height ~300 m

Wind direction divergence of less than 5 deg produces a height difference of 200 m or 20%

Solutions:

- Digitize numerous polygonal strips, each with slightly different wind directions
- Digitize numerous lines with the "Retrieve along line" digitizing option

Wind Direction – Along-Track



Issue: Plumes that trend nearly along-track have poor quality retrievals – both in coverage and in accuracy.

Solution: Adjust the wind direction by 5-10 degrees and test the height sensitivity to ensure accuracy is not excessively compromised.

Wind direction approaches along-track direction

Wind-corrected heights decline

Quality of retrieved wind-corrected heights declines

Zero-wind heights are not affected

Wind Direction: Tips for Determining

- A visible source of smoke, dust or ash at terrain level and a linear aerosol plume emanating from that source are excellent indicators of wind direction
- MODIS fire pixels provide independent evidence of the location of a smoke source
- Motion of aerosol shadows on the ground are true indicators of direction of motion
- An aerosol with apparent top-to-bottom motion in forward animation must be near the surface and have rapid, wind-driven, top-to-bottom motion that overwhelms apparent motion due to parallax, which is always bottom-to-top
- Reanalysis or other meteorological data can be used as external sources of wind direction in some cases – especially useful for cloud studies
- The across-track direction of motion (toward the left or right half-plane) can usually be determined in forward animation and is reliable – along-track direction of motion (toward the upper or lower half-plane) cannot usually be determined
- The across-track direction of motion can also be determined in many cases by digitizing the feature multiple times with wind directions toward the left and right half-plane – only the correct half-plane direction should produce good retrievals
- If wind direction cannot be determined, it is safest to digitize an aerosol feature as a "cloud", by specifying the "Use no wind direction" option, rather than as a "plume"

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Aerosol Properties: Low Optical Depth - 1

Issue: When aerosol reflectivity is low relative to the underlying surface as viewed by the nadir camera, the image matcher will find a match on the surface rather than on the aerosol.

Mt. Etna erupts - October 27, 2002
Aerosol is apparent in Cf camera but not in An

Solutions:

- **In Digitizing Options dialog, select a larger image matcher and reduce the retrieval precision**
- **If over land and the terrain is bright, try retrieving with the blue band – especially useful for smoke**
- **Some optically thin aerosols are not amenable to stereoscopic height retrieval**

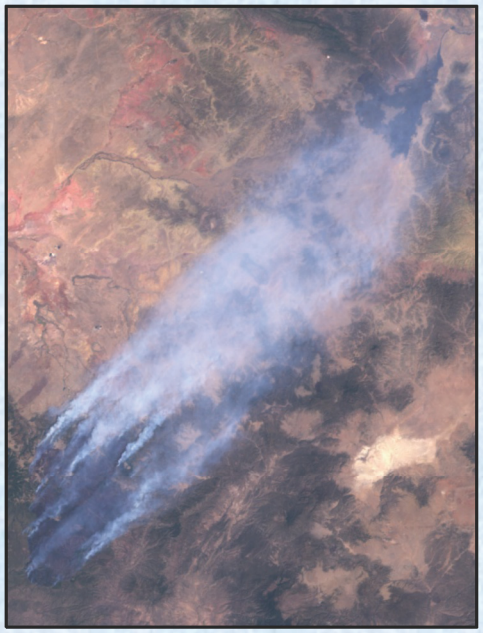
Aerosol Properties: Low Optical Depth - 2

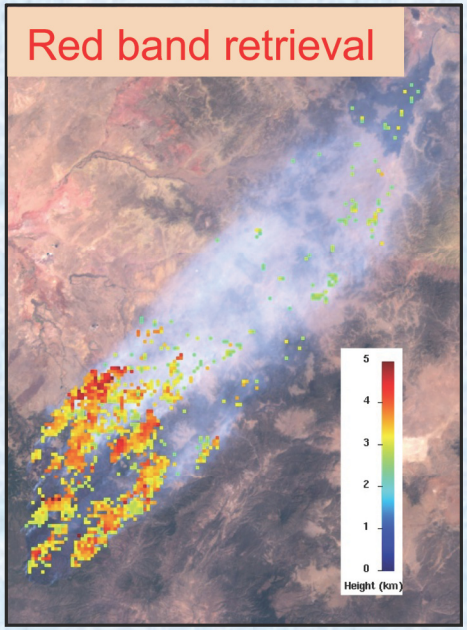
Greatest improvements in retrieval results for blue-band .vs. red-band are obtained:

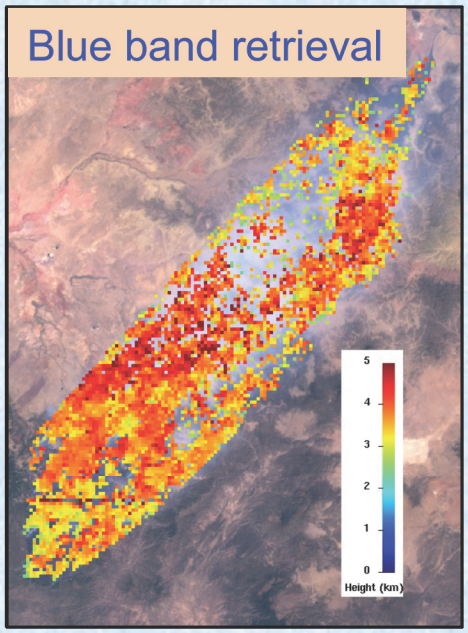
- **for smoke that preferentially scatters blue light**
- **over bright terrains that preferentially scatter red light**

Achieving high vertical and horizontal resolution is possible because:

- **blue-band images are interpolated to 275 m resolution with red-band data from same camera**
- **correlation results from image matcher are interpolated to sub-pixel resolution**
- **height retrievals from multiple camera pairs are averaged**







Wallow fire over eastern Arizona, June 7, 2011

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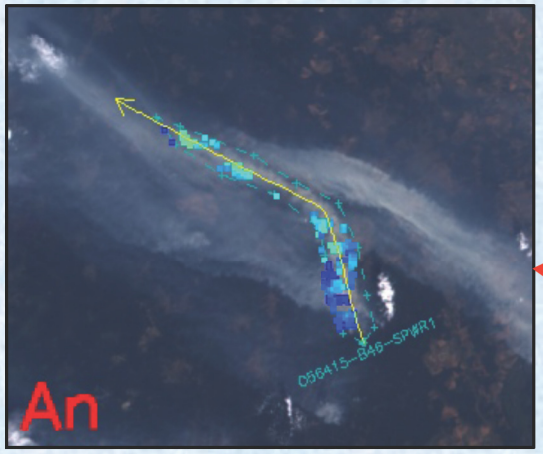
Other Complexities: Poor Camera Co-Registration - 1

Issue: Obtaining accurate height and winds requires cameras to be well registered to the terrain and to each other. Otherwise, disparities due to registration error are added to parallax & wind disparities and contribute to poor retrieval results.

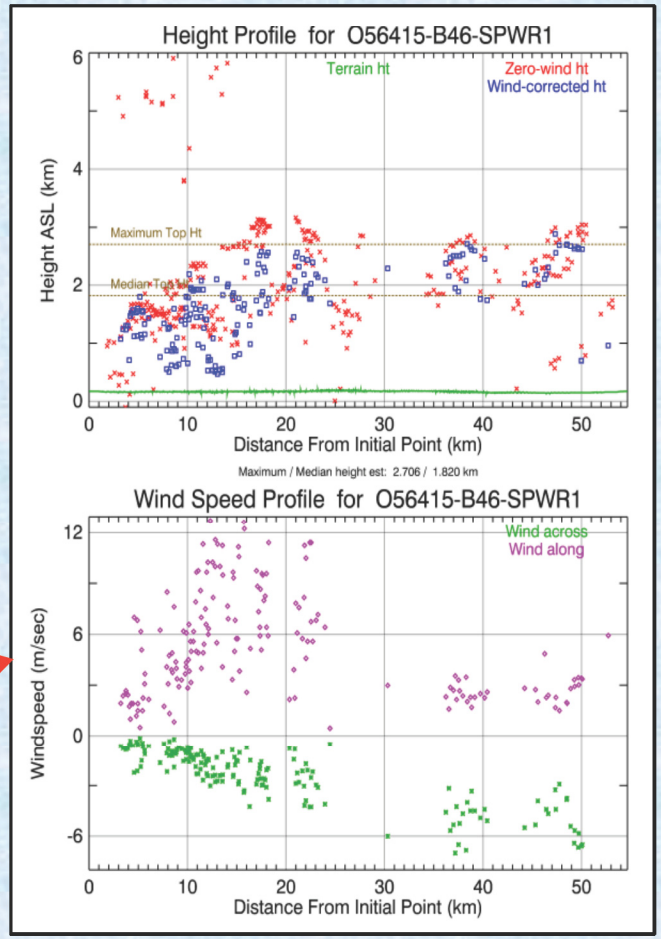


Solution:

- Always check camera registration before digitizing and attempt to repair it if needed

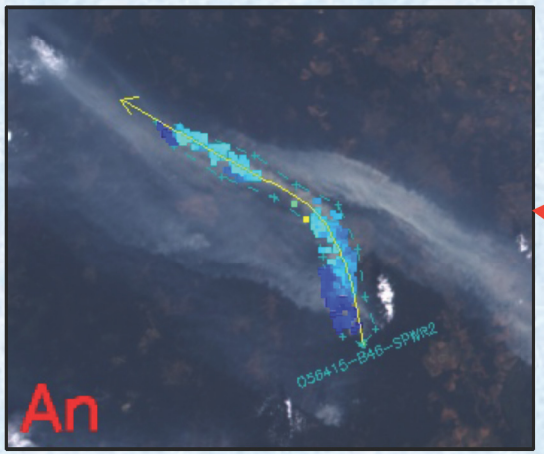
Plumes from fires near Moscow July 27, 2010 Orbit 56415

Retrieval results before registration correction: poor coverage and large scatter in heights and winds



Other Complexities: Poor Camera Co-Registration - 1

Issue: Obtaining accurate height retrievals requires all cameras to be properly registered to the terrain. When this is violated, disparities due to registration error are added to parallax & wind disparities and contribute to faulty retrieved heights.

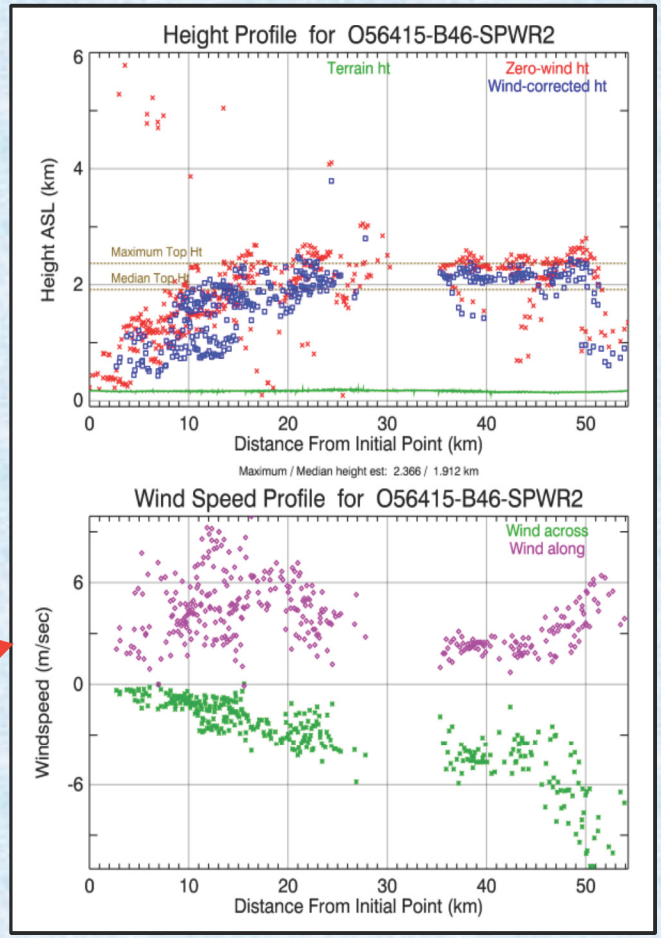


Solution:

- Always check camera registration before digitizing and attempt to repair it if needed.

Plumes from fires near Moscow July 27, 2010 Orbit 56415

Retrieval results <u>after</u> registration correction of ~ 1 pixel along-track in several cameras: improved coverage and less scatter in heights and winds

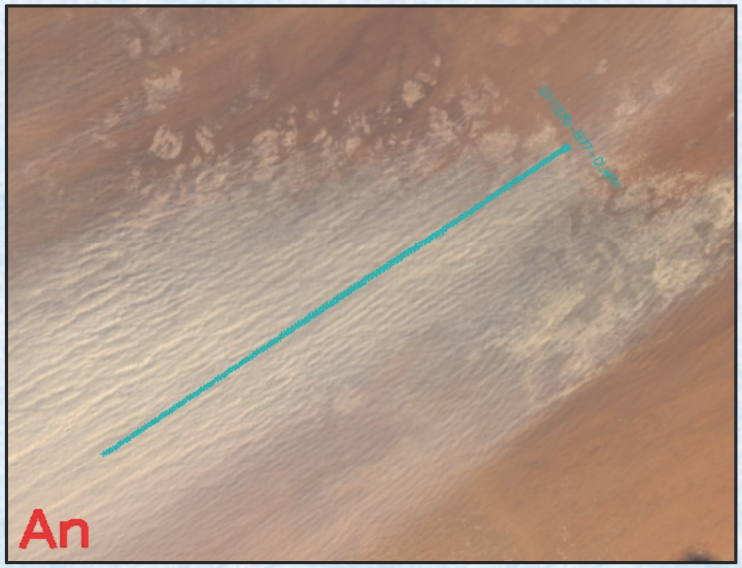


Other Complexities: Aerosol Near Surface

Issue: Attempts to retrieve heights on aerosols very near the surface will fail if the value set in the Digitizing Option "Min height above terrain" is greater then the aerosol's height.

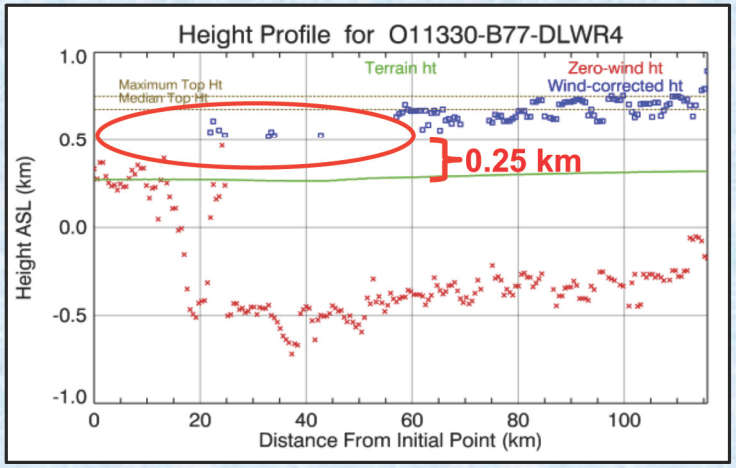
Solution:

- **Reduce the "Min height" value only if the cameras are well registered. This parameter serves to filter out misregistration noise.**

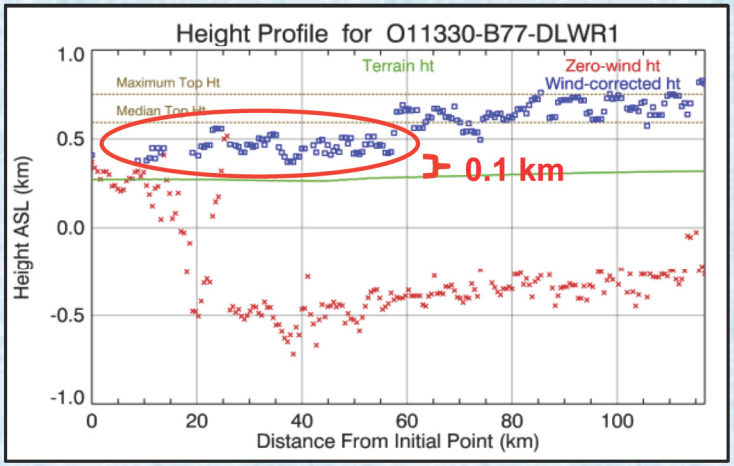


Bodele Depression dust, Chad
Orbit 11330, February 3, 2002

Results with "Min height above terrain" option set to default 0.25 km



Results with "Min height above terrain" option set to 0.1 km



Additional Complexities

- Vertical motion of aerosol
- Homogeneous aerosol
- Time-varying wind direction
- High-relief terrain

Contents

Digitizing Options Dialog Box

Selection determines the name of plume and the color of digitized polygon

If you have an IDL license, a 9-camera MPG or MP4 animation is saved – otherwise 9 JPEG images are saved

An image containing data from MISR standard Aerosol product is saved

Top-of-atmosphere albedos are computed and saved

You will be asked for a MISR standard Stereo product file, and those heights and winds will be added to the profile plots

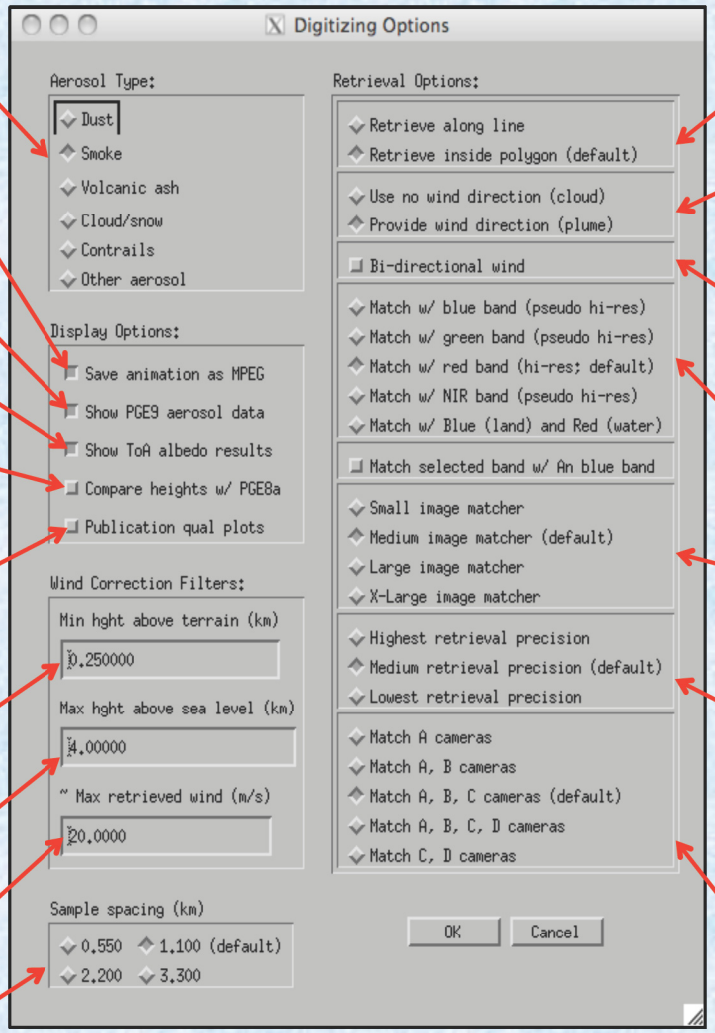
Profile plots will be drawn with higher resolution and fewer annotations and camera names are not written on images

No wind-corrected heights below this distance above terrain will be retrieved

No wind-corrected heights above this distance above sea level will be retrieved

No wind speeds above this value will be retrieved

Grid spacing between points in the plume polygon where retrievals are attempted



If cursor hovers over buttons, context-sensitive help is shown

Retrieve heights and winds either along a digitized line or inside a digitized polygon – along line requires using "wind direction"

Compute only zero-wind heights (cloud) or compute zero-wind heights plus winds and wind-corrected heights (plume) – no wind direction requires "Retrieve inside polygon"

Digitized wind directions as well as 180 degree opposite wind directions are used – e.g. across eye of hurricane

Select MISR band(s) to use in the image matching step – if plume extends over land and water, "Match w/ Blue and Red" helps

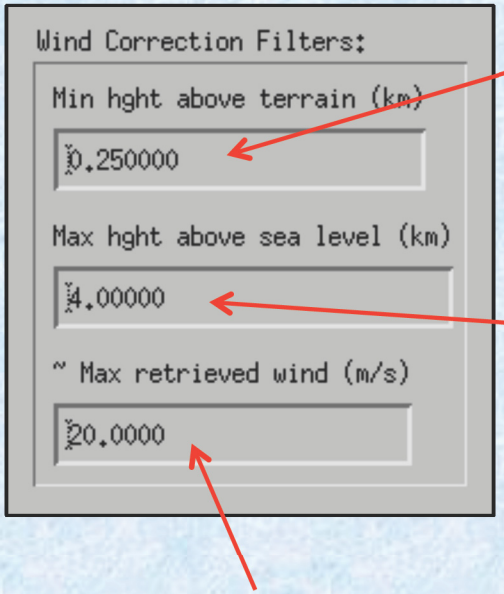
Select the size of the image matcher to use – larger is slower and smooths results but increases the number of retrievals

Select the "quality" of the retrieval – higher provides greater confidence in results but reduces the number of retrievals – based on the number of camera pairs returning similar results and threshold on similarity

Select which cameras to match against the An camera – D cameras slow retrievals and are often not useful – for "Match A cameras", use "Lowest retrieval precision"

Wind Correction Filters

Objective: To provide thresholds on the wind-corrected heights and wind speeds retrieved by MINX so unwanted retrievals on terrain and clouds can be excluded. Secondarily, to limit the computations performed in searching for solutions during forward modeling.



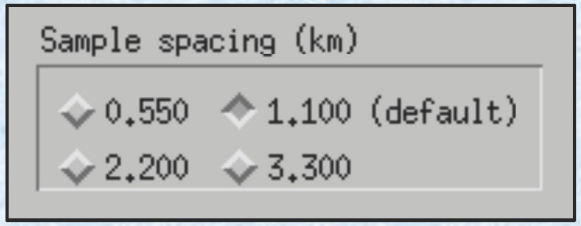
No wind-corrected heights less than this height above the terrain will be retrieved – use this to exclude matches on the terrain from being reported as wind-corrected heights

No wind-corrected heights greater than this value above sea level will be retrieved – use this, together with Min hght, to prevent matches on clouds from being reported as wind-corrected heights (only effective when clouds are at a different height than the target aerosol)

No wind speeds greater than this value will be retrieved - this primarily serves to reduce computation time during forward modeling

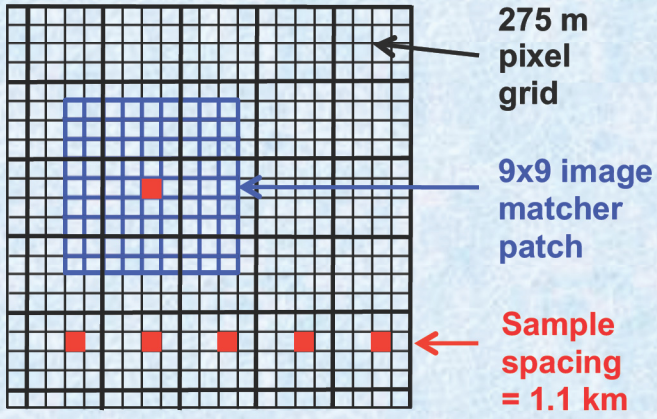
Sample Spacing - 1

Objective: To determine the spatial frequency at which height and wind speed retrievals are attempted. Also, to control the time required to perform retrievals.



- Spacing of samples (or retrieval points) applies to both across and along dimensions – for each doubling of sample spacing, the number of samples decreases by 4 as does retrieval time

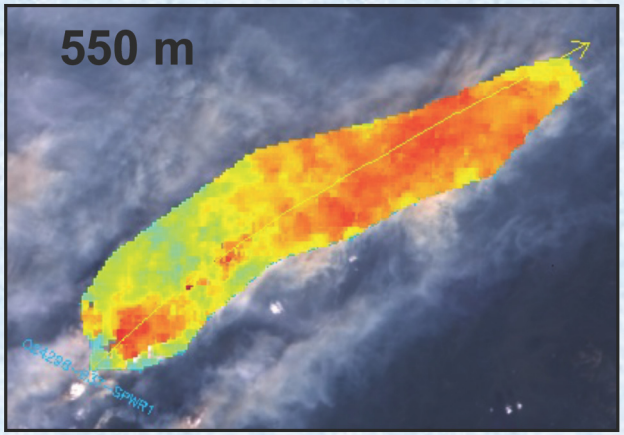
- Retrievals are based on 275 m pixels - MINX pixel spacing options are 2 (0.55 km), 4 (1.1 km), 8 (2.2 km) and 12 (3.3 km)
- Default spacing for retrievals with wind-correction (plumes) is 1.1 km – for retrievals without wind-correction (clouds), it is 2.2 km
- Retrieved values are displayed on the animation image as colored squares the size of sample spacing – don't confuse this with the size of the patches used in image matching
- Patches used in image matching are from 9 to ~15 pixels on a side, so each sample shares contributions to retrieved height with adjacent samples

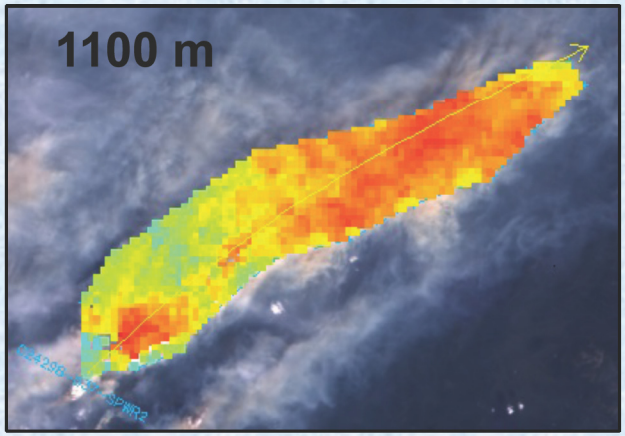


Sample Spacing - 2

Examples of height retrievals using 4 different sample spacing options

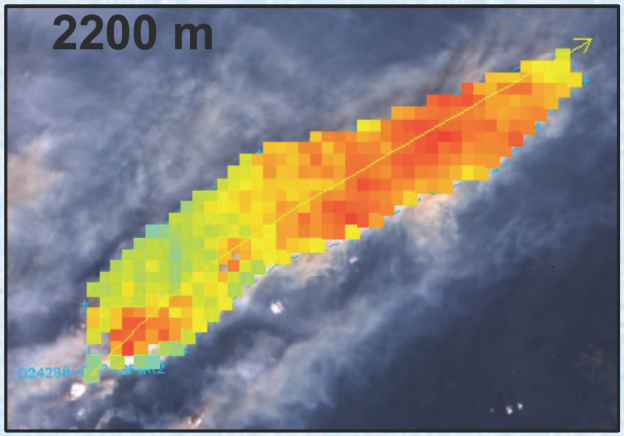
Matcher patch size is 9x9 pixels or about 2.5 km in all cases

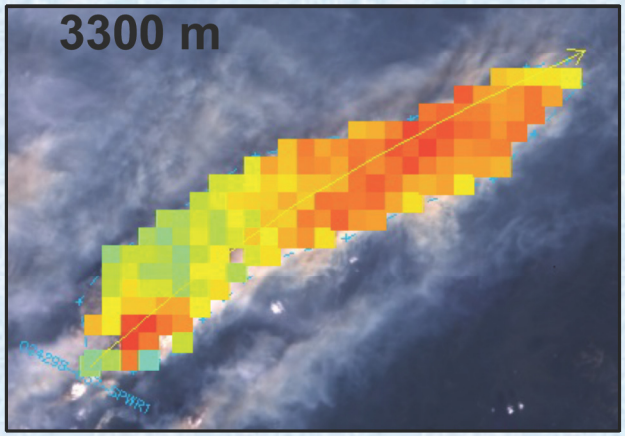




Alaska smoke plume – orbit 24298

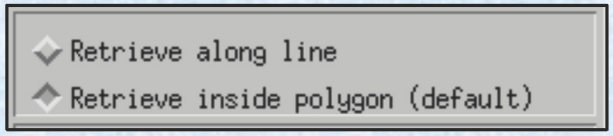
115 km



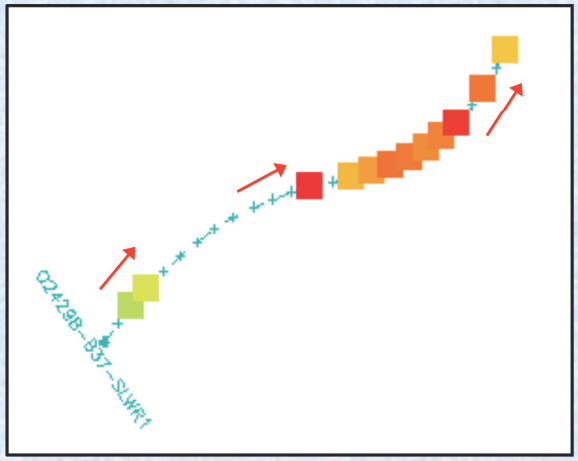


Line or Polygon - 1

Objective: To choose whether heights and winds will be retrieved at sample points along a line or at sample points inside a polygon. Also, to control the time required to perform retrievals.



- **Retrieve along line:**
  - Points digitized by user are connected by a splined curve that is resampled at uniform spacing according to the value in the "Sample spacing" option
  - The resampled line doubles as the wind direction line
  - This option disables "Use no wind direction (cloud)" option
  - Use this for a quick analysis or to display a plume or terrain height profile without clutter or if a plume has variable wind directions (e.g. if it fans out from the source)
- **Retrieve inside polygon:**
  - Sample points are created on a regular grid with spacing set by the "Sample spacing" option
  - If "Provide wind direction" is chosen, the direction used for wind correction at each sample point is the wind direction at the nearest point on the direction line
  - The wind-direction line does not need to be contained within the polygon – a line in any direction will result in retrieval attempts using that direction



Example of splined line defined by 4 digitized points and resampled to 3.3 km spacing

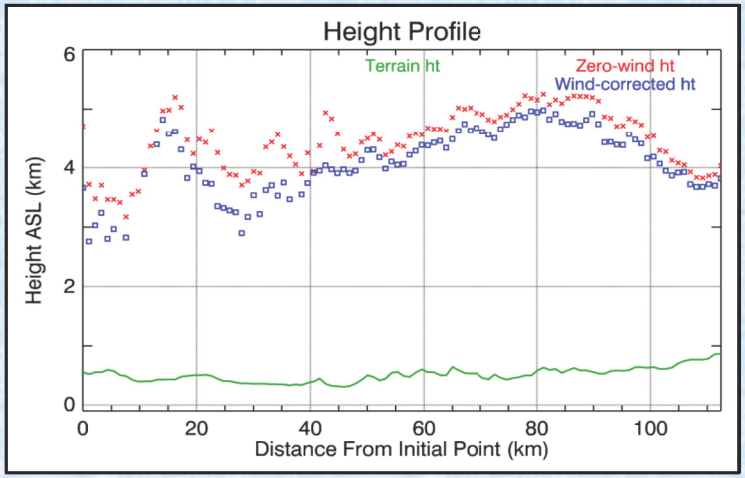
Dashes connect resampled points indicated by + symbols

Colored squares at points with successful height retrievals are 3.3 km on a side to highlight sample spacing

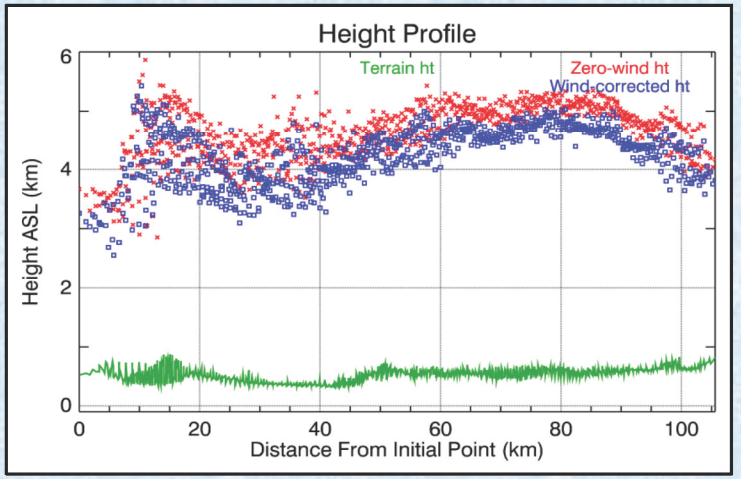
Arrows are wind direction vectors near selected points

Line or Polygon - 2

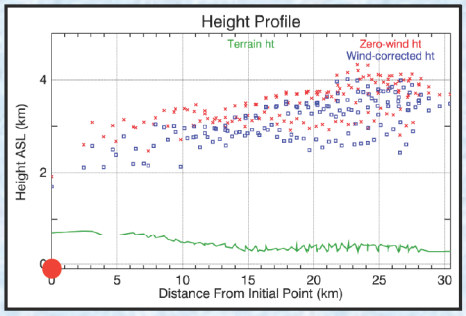
Height profiles for Alaskan plume on orbit 24298

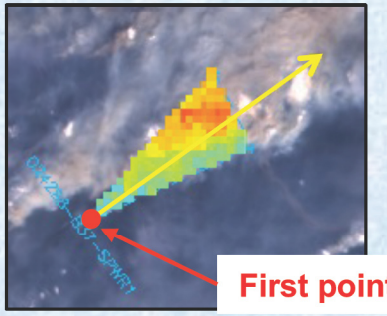


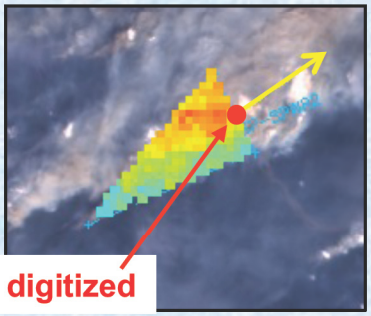
Terrain and aerosol heights retrieved along a line are single-valued and show fine detail

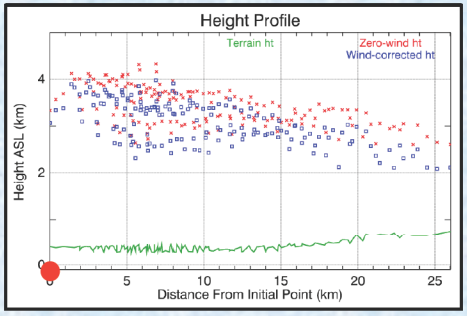


Terrain and aerosol heights retrieved in broad polygon have a large spread in height values





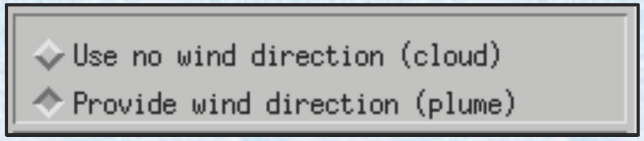




Plumes digitized starting from opposite ends w/ same wind vector
Same heights are retrieved, but height profiles are reversed

Provide Wind Direction or Not

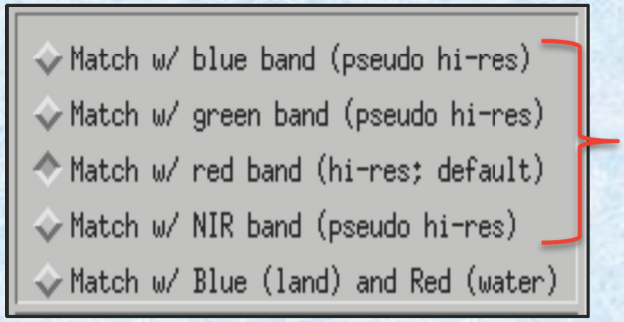
Objective: To choose whether to retrieve only zero-wind heights or to retrieve wind speed and wind-corrected heights as well.

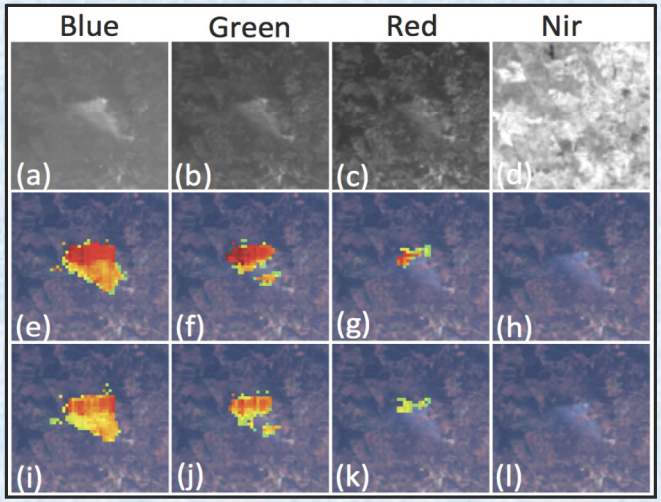


- **Use no wind direction:**
  - **MINX use of the term "cloud" means a digitized aerosol region for which no wind direction is provided, generally because no aerosol source location or other clues are available from which to deduce the direction of motion**
  - **Option computes zero-wind height only which assumes entire disparity is due to camera parallax**
  - **Significant height errors may result from assuming zero-wind heights are real – a sensitivity study performed by digitizing with different wind directions can provide error bars**
  - **If wind direction is exactly across-track, zero-wind height equals wind-corrected height**
- **Provide wind direction:**
  - **The term "plume" as used by MINX designates a digitized aerosol region for which wind direction is provided (from any source including from meteorological data)**
  - **Option computes zero-wind height plus wind speeds and wind-corrected heights by separating camera disparities into parallax and wind components**

Band-Specific Height Retrievals

Objective: To choose the color band best matched with the scene to retrieve aerosol heights.

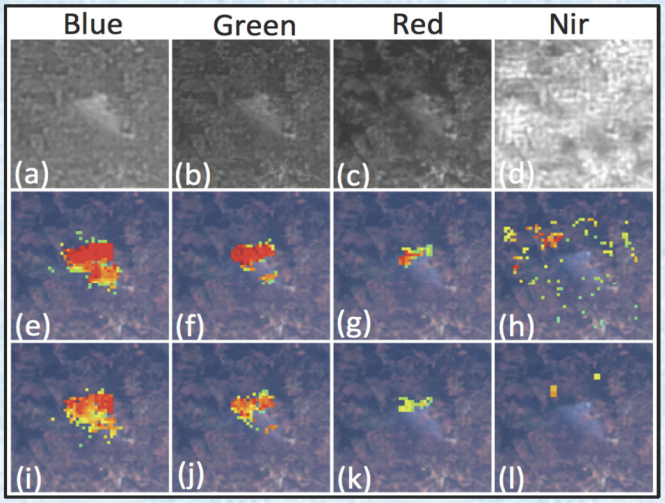




Aa camera **local mode** images

Zero-wind height

Wind-corrected height



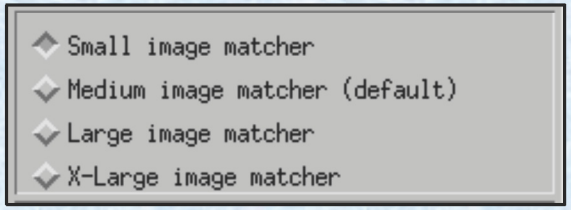
Aa camera **pseudo-local mode** images

Zero-wind height

Wind-corrected height

Image Matcher Size - 1

Objective: To .



- **Important not to digitize too far outside bounds of plume, especially with larger matchers**
- **Small image matcher requires very good data quality**
- **Medium matcher optimal for most cases**
- **Larger matchers often have a larger retrieval success rate**
- **Use X-large matcher only if detail is not important**
- **Larger matchers require much more CPU time!**

Image Matcher Size - 2

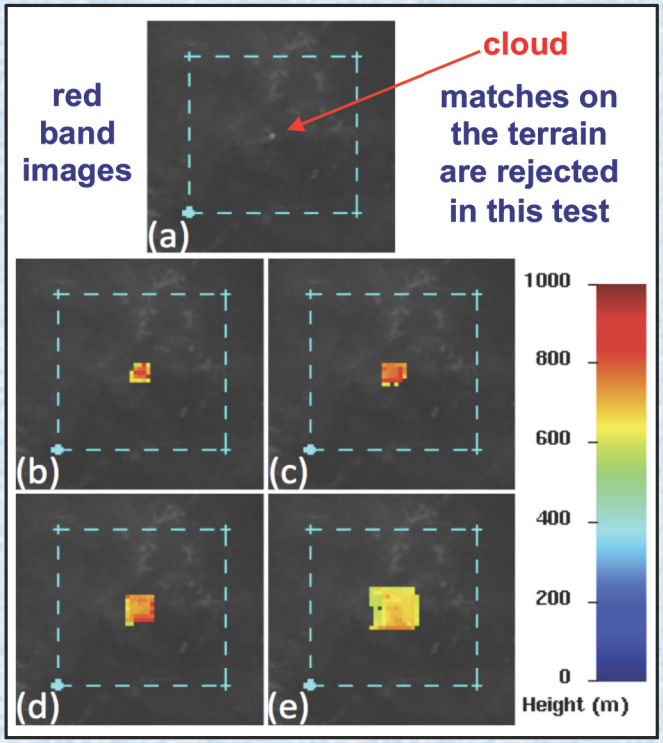
Image matching smears small Features:

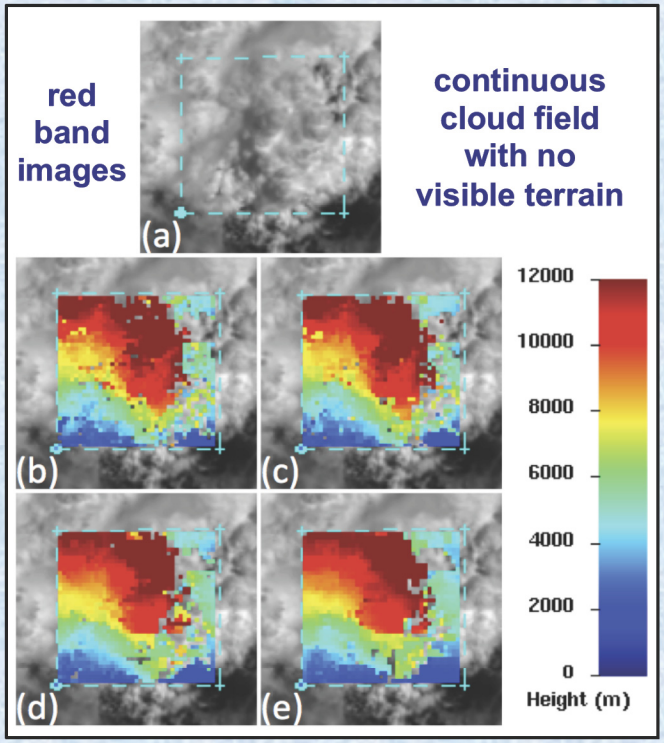
- Point-source cloud at image center
- Height of point feature is smeared over an area ≅ reference patch size

Image matching smooths Textures:

- Cloud field fills image
- Retrieved heights are smoothed more the larger the reference patch size

Zero-wind heights are retrieved within dashed cyan boxes w/ 550 meter sample spacing





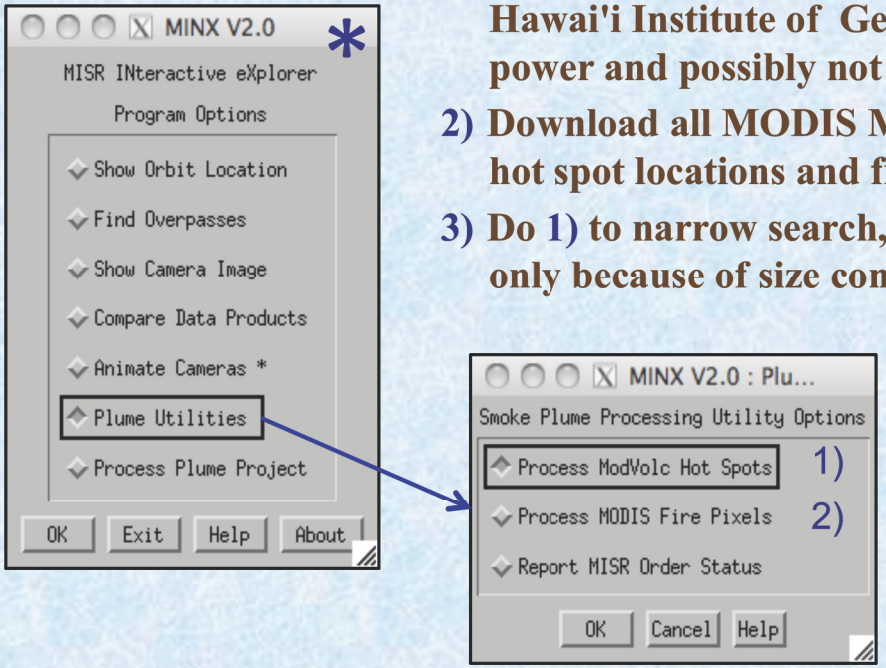
Square matcher sizes per camera (N x 275 m pixels): (b) Small matcher (A=7, B=7, C=9, D=11) (c) Medium matcher (A=9, B=11, C=11, D=13) (d) Large matcher (A=13, B=15, C=17, D=19) (e) Extra large matcher (A=23, B=25, C=27, D=29)

Contents

Plume Utilities

Objective: To facilitate processing large smoke plume projects by using MODIS hotspot detections to select MISR orbits and blocks that may contain plumes. Also to capture MODIS fire radiative power and report it with other smoke plume data.

- **Too expensive to download all MISR orbits in project area and search to find smoke plumes**
- **Rely on MODIS (Terra only) fire detections to reduce download burden by factor of ~100**
- **3 alternatives for acquiring MODIS "Fire Pixel" or "Hot Spot" location data:**



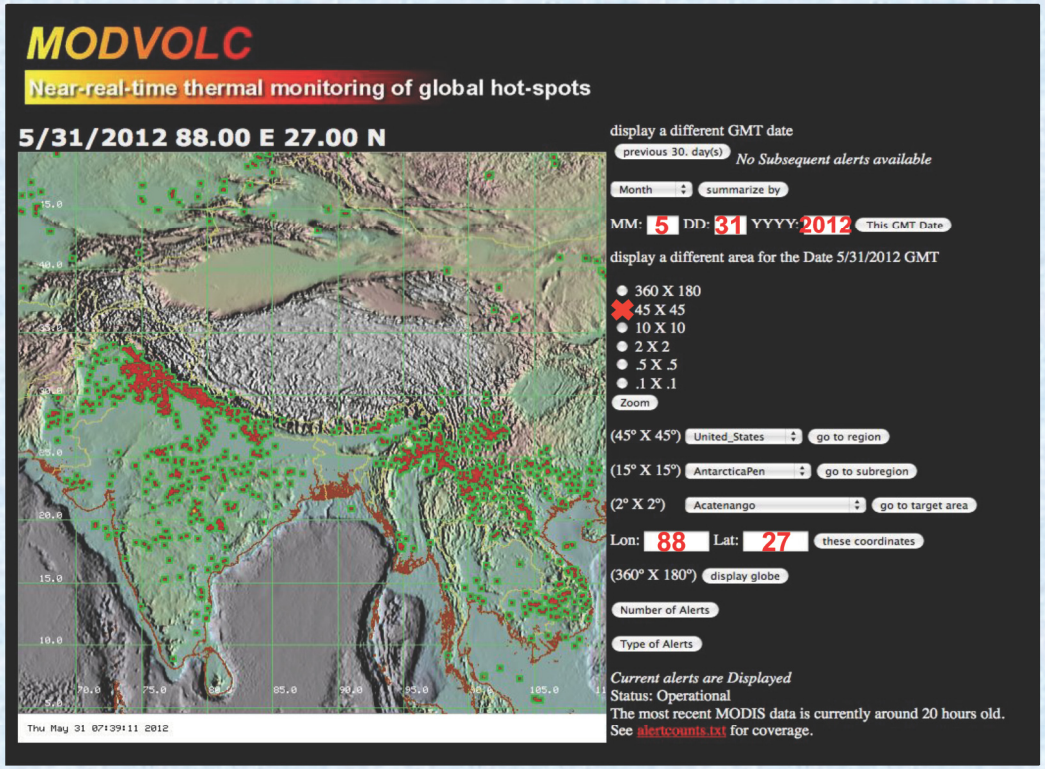
1) **Download ModVolc hot spot data summarizing MODIS detections - from Hawai'i Institute of Geophysics and Planetology (only locations, no fire power and possibly not as reliable as MODIS data) OR**
2) **Download all MODIS MOD14 granules for a project area and search for hot spot locations and fire power OR**
3) **Do 1) to narrow search, followed by 2) - preferred for very large projects only because of size constraints on thousands of MODIS granules.**

ModVolc hot spots for a project area:

- **A fraction the size of full MODIS granules**
- **May not be as reliable in some areas**
- **Searchable on the web by geographic coordinates and time**
- **Downloadable as text files with one fire pixel per record**

Plume Utilities – Process ModVolc Hot Spots - 1

- **Download a condensed set of MODIS hot spot data for a geographic area and time range from ModVolc website: http://modis.higp.hawaii.edu/**



① Determine your project's geographic and date ranges

② Decide which of the six square retrieval size ranges is best for your project, select it, press "Zoom" and wait for map to update (you may need to repeat the procedure below with multiple squares)

③ In the boxes labeled "Lon:" and "Lat:", enter the center longitude and latitude for your region of interest, press the "these coordinates" button and wait for map to update

④ In the dropdown listbox with default value of "Day", select the period of time for which you wish to retrieve data, press "summarize by" and wait for map to update

⑤ In the "MM:", "DD:", and "YYYY:" boxes, enter the ending date for the period you want to retrieve, press "This GMT Date" and wait for map to update

⑥ Click on red link at the bottom labeled "Text Alert File" (not shown) to go to page containing ASCII results

⑦ On your browser's "File" menu, select "Save Page As…" and save to a file named "ModVolc_<project>.txt", where <project> is the name of your project - if you selected and downloaded data from multiple region squares, concatenate the files into one file with this name

Plume Utilities – Process ModVolc Hot Spots - 2

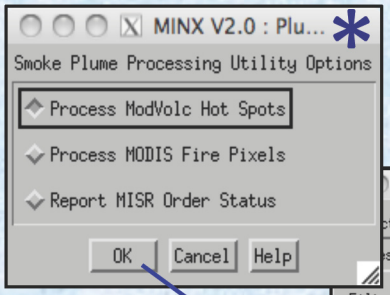
Sample ModVolc fire pixel file

UNIX_Time	Sat	Year	Mo	Dy	Hr	Mn	Longitude	Latitude	B21	B22	B6	B31	B32	SatZen	SatAzi	SunZen	SunAzi	Line	Samp	Ratio	Glint
1199115300	T	2007	12	31	05	35	84.432106	28.454927	3.733	-10.000	9.770	7.378	6.996	46.11	-77.86	52.88	165.57	473	1177	-0.357	47.557
1199115300	T	2007	12	31	05	35	85.997452	28.160923	2.304	-10.000	8.387	7.205	6.877	53.27	-76.49	52.31	167.28	468	1247	-0.559	49.777
1199081400	A	2007	12	30	20	10	86.095711	23.684803	1.187	1.145	177.141	7.547	7.210	15.11	-81.76	154.01	94.49	602	844	-0.726	139.289
1199037600	A	2007	12	30	08	00	84.415016	28.459906	9.990	-10.000	14.834	8.953	8.345	44.99	-96.49	56.95	-153.54	1704	188	0.057	86.020
1199026200	T	2007	12	30	04	50	84.778687	28.446533	6.048	-10.000	15.171	10.130	9.543	30.66	97.98	55.98	154.11	1354	340	-0.277	76.064
1198982700	T	2007	12	29	16	45	85.148216	28.227318	0.653	0.691	169.026	6.329	6.171	31.11	-97.40	158.25	-82.51	873	334	-0.799	168.947
1198721700	T	2007	12	26	16	15	86.088821	23.680870	0.855	0.888	169.026	8.061	7.627	32.45	79.70	152.35	-95.52	115	1033	-0.791	119.890
1198549500	T	2007	12	24	16	25	86.392899	23.772381	0.905	0.906	169.026	8.351	7.909	5.09	83.48	155.67	-94.74	1016	734	-0.794	149.991
1198116300	T	2007	12	19	16	05	87.241096	23.560938	0.874	0.875	169.026	7.388	7.082	35.14	79.70	152.75	-95.97	1636	1063	-0.780	116.753
1197870900	A	2007	12	16	19	55	86.090881	23.680214	0.948	0.925	177.143	7.683	7.310	12.20	97.57	155.27	94.41	1728	542	-0.775	168.408
1197339300	T	2007	12	10	16	15	87.243050	23.557714	0.902	0.852	168.883	7.766	7.403	24.40	80.67	155.04	-94.01	37	947	-0.794	130.711
1196994900	T	2007	12	06	16	35	82.755440	24.144701	0.930	0.969	168.883	7.556	7.153	9.23	80.96	156.99	-91.44	1974	780	-0.761	146.717
1196921700	A	2007	12	05	20	15	86.102715	23.686962	0.962	0.956	177.145	7.816	7.394	27.42	-79.53	149.83	94.02	1057	979	-0.771	123.085
1196261400	T	2007	11	28	04	50	87.001198	26.642347	4.124	-10.000	13.424	9.455	8.680	10.46	97.98	50.48	158.87	1418	561	-0.419	56.391
1195917300	T	2007	11	24	05	15	81.619591	29.902927	3.302	-10.000	16.158	8.813	8.410	10.58	97.75	52.60	160.76	919	560	-0.526	58.079
1195784700	T	2007	11	22	16	25	86.392342	23.772024	0.924	0.932	168.883	8.623	8.129	5.48	86.12	158.08	-85.36	899	738	-0.794	152.154
1195711500	A	2007	11	21	20	05	86.097397	23.681507	0.875	0.880	177.014	8.070	7.639	1.60	-94.08	151.09	88.66	122	694	-0.793	149.550
1195539300	A	2007	11	19	20	15	86.103180	23.686689	0.927	0.937	177.016	8.209	7.753	27.31	-80.16	148.05	88.92	1024	978	-0.784	121.628
1194835500	T	2007	11	11	16	45	82.753380	24.148623	0.905	0.924	168.793	8.484	8.018	4.06	-97.12	158.54	-76.12	272	632	-0.793	162.133
1194663300	T	2007	11	09	16	55	82.755974	24.144241	0.968	0.938	168.793	8.520	8.041	29.32	-98.38	161.06	-71.92	1168	354	-0.791	165.558
1194574200	T	2007	11	08	16	10	87.235504	23.556698	0.801	0.918	168.867	8.568	7.987	24.95	79.13	155.56	-79.04	1910	952	-0.794	130.494
1194501000	A	2007	11	07	19	50	86.095741	23.680073	1.052	1.275	177.023	8.452	7.875	24.95	99.06	152.35	79.37	1210	401	-0.721	171.188
1194329100	A	2007	11	05	20	05	86.399284	23.771706	0.979	1.004	177.025	8.763	8.120	4.00	-84.86	149.08	80.86	93	721	-0.780	145.247
1194230100	T	2007	11	04	16	35	82.750717	24.146837	0.990	1.054	168.793	8.514	8.023	9.57	80.90	156.47	-73.63	1864	783	-0.768	146.609
1194230100	T	2007	11	04	16	35	86.391319	23.769669	0.978	0.971	168.793	8.817	8.180	21.37	-99.12	159.68	-70.58	1768	441	-0.788	169.724
1194156900	A	2007	11	03	20	15	82.761208	24.149549	0.969	1.003	177.026	8.410	7.951	1.71	101.93	149.31	78.32	1035	658	-0.776	151.425
1194156900	A	2007	11	03	20	15	86.102310	23.687292	0.924	0.964	177.026	8.520	7.933	27.31	-79.35	146.39	81.30	1028	978	-0.783	120.569
1194058200	T	2007	11	02	16	50	82.754509	24.145805	0.965	1.001	168.793	8.618	8.071	17.68	-98.95	158.82	-68.04	756	481	-0.779	169.071

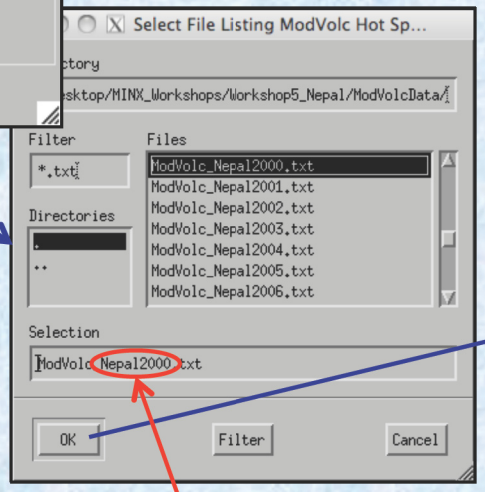
"Sat" column is satellite where T = Terra and A = Aqua

Columns circled in red are used by MINX

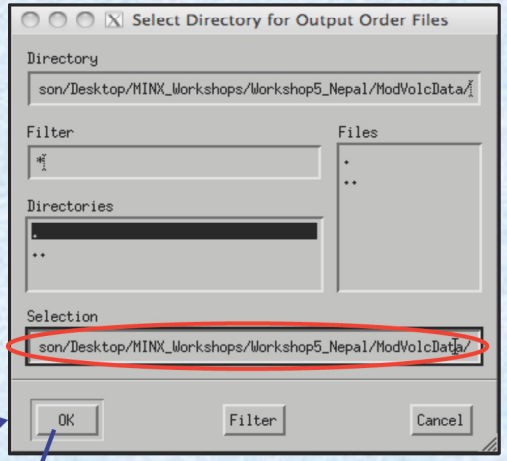
Plume Utilities – Process ModVolc Hot Spots - 3



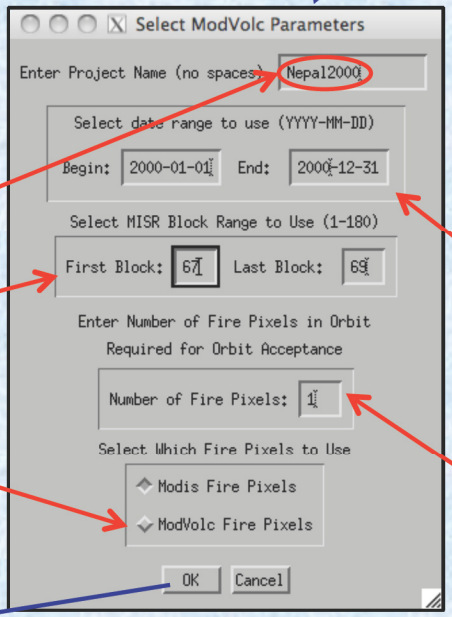
Select "Process ModVolc Hot Spots" to show dialog box requesting name of file containing ModVolc data downloaded from website



Select file and click "OK" to show dialog box requesting name of directory where output files will be stored



Select directory and click "OK" to show dialog box requesting project information



Use consistent project name throughout

Enter block range for project – this subsets input fire pixels to a smaller geographic range – block number is an effective proxy for latitude

To retrieve MODIS fire power when you digitize plumes, you must choose "MODIS Fire Pixels", download MODIS granules and process them with "Process MODIS Fire Pixels" option
To only show fire pixel locations on MISR images, then choose "ModVolc Fire Pixels"

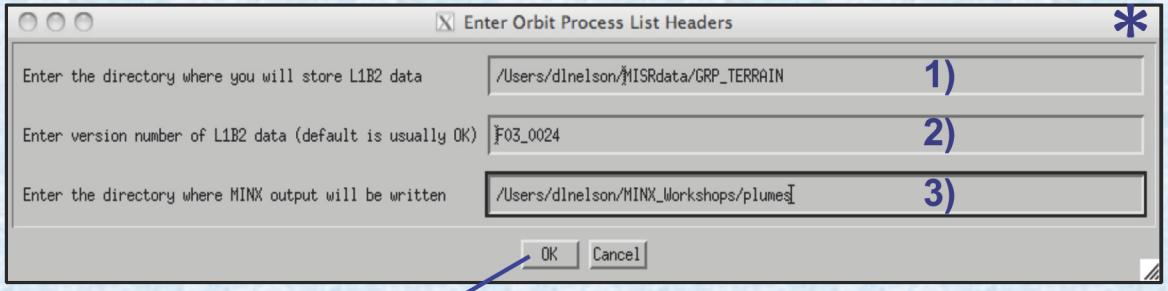
Enter time range for project – this subsets input fire pixels to a smaller time range

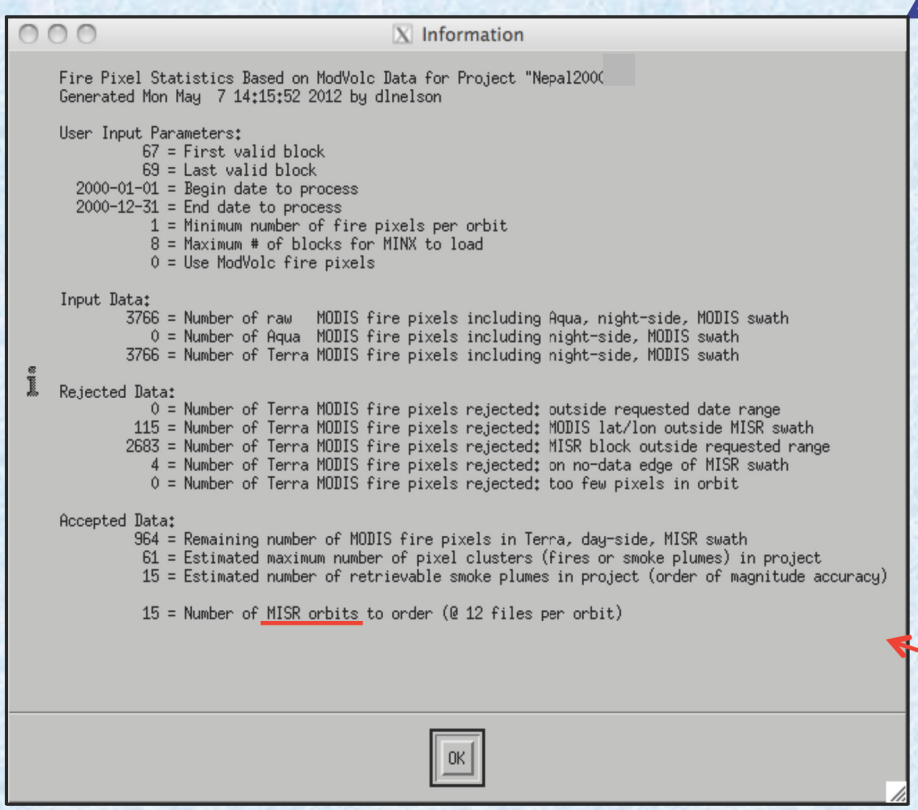
You may want to exclude MISR orbits with a very small number of fire pixels

See * in next slides

Plume Utilities – Process ModVolc Hot Spots - 4

If you selected "ModVolc Fire Pixels" in the "Select ModVolc Parameters" dialog box, you will see these dialog boxes next – otherwise skip this slide and the next





These parameters are written at the top of the "MisrProcessList_<project>.txt" file:

1) **Full directory name where you will store downloaded MISR GRP_TERRAIN or GRP_ELLIPSOID files for input to digitizing**
2) **Version number of GRP_.... Files**
3) **Directory name where MINX images, graphs and raw data files from plume digitizing will be saved**

After clearing these dialog boxes, find your output files in the directory specified in the "Select Directory for Output Order Files" dialog:

- **MisrOrderList_<project>.txt**
- **MisrProcessList_<project>.txt**
- **ModVolcFirePixReport_<project>.log**
- **FirePixels_0<orbit>_<project>.txt (1 / orbit)**

Plume Utilities – Process ModVolc Hot Spots – 5

Output Files from "Process ModVolc Hot Spots"

Sample: MisrOrderList_Nepal2000.txt

```
49117,49219,49554,49627,49656,49685,49758,49787,
50384,50457,50486,50559,50588,50661,50792,50821,
50952
```

List of MISR orbits to be cut-and-pasted into the "Orbits:" text box in Step 2a: of the MISR "Order and Customization Tool"

Sample: FirePixels_02852_Nepal2000.txt

```
Fire pixels from ModVolc project : Nepal2000
2852 / 141 / 2000-07-01  : orbit/path/date
 Longitude  Latitude Blk Samp Line
  degrees    degrees       0-based
  86.63058  26.82733  69 1534  249
  86.64109  26.82565  69 1538  249
  86.45438  26.72519  69 1475  297
  86.46477  26.72354  69 1479  297
  86.47516  26.72189  69 1483  297
  86.49596  26.71858  69 1491  298
  86.51679  26.71527  69 1498  298
  86.52721  26.71361  69 1502  299
  86.46581  26.70623  69 1480  304
  86.51787  26.69807  69 1499  305
  86.52831  26.69643  69 1503  305
  86.46407  26.69711  69 1480  308
  86.47447  26.69547  69 1484  308
  86.51611  26.68893  69 1499  309
  86.52654  26.68729  69 1503  309
  86.45192  26.68962  69 1476  311
  86.47271  26.68635  69 1484  312
  86.48312  26.68472  69 1487  312
  86.50394  26.68144  69 1495  312
  86.51437  26.67980  69 1499  313
```

File containing a list of fire pixels for one orbit is to be selected when digitizing smoke plumes for that orbit

Sample: MisrProcessList_Nepal2000.txt

```
/Users/dlnelson/MISRdata/GRP_TERRAIN
F03_0024
/Users/dlnelson/MINX_Workshops/plumes
 1658    67    69     2000-04-10      05:30:00
 1687    67    69     2000-04-12      05:20:00
 2095    66    69     2000-05-10      05:45:00
 2517    68    70     2000-06-08      05:15:00
 2561    68    70     2000-06-11      05:45:00
 2590    68    70     2000-06-13      05:30:00
 2692    68    70     2000-06-20      05:35:00
 2721    66    68     2000-06-22      05:25:00
 2750    68    70     2000-06-24      05:15:00
 2794    68    70     2000-06-27      05:45:00
 2823    67    70     2000-06-29      05:30:00
 2852    68    70     2000-07-01      05:20:00
 2954    66    70     2000-07-08      05:25:00
 5313    67    69     2000-12-17      05:10:00
 5386    66    68     2000-12-22      05:30:00
```

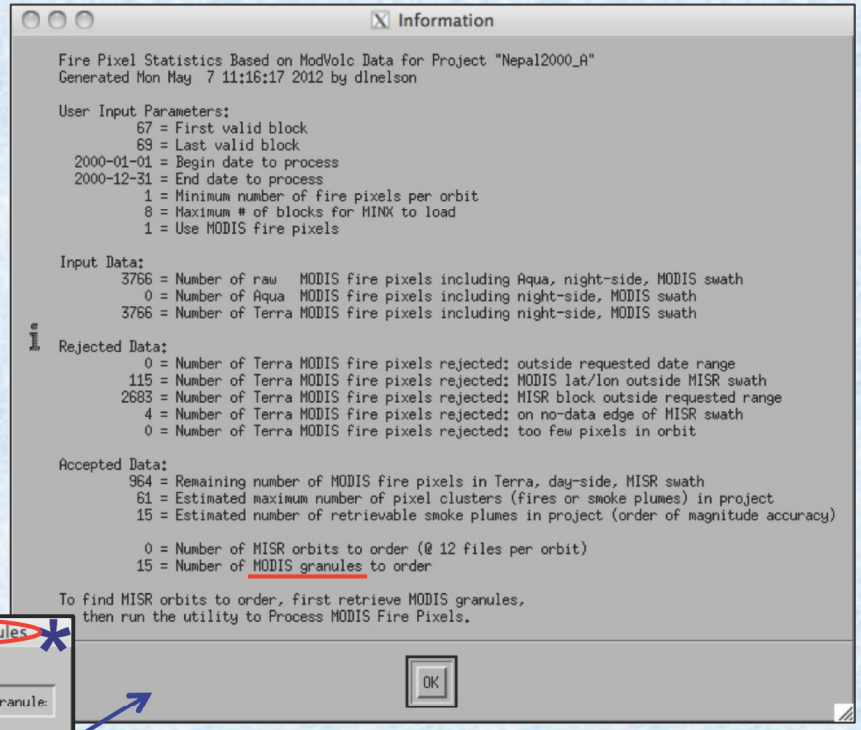
Rename this file to "PlumeProjOrbitList.txt" and copy into your home directory

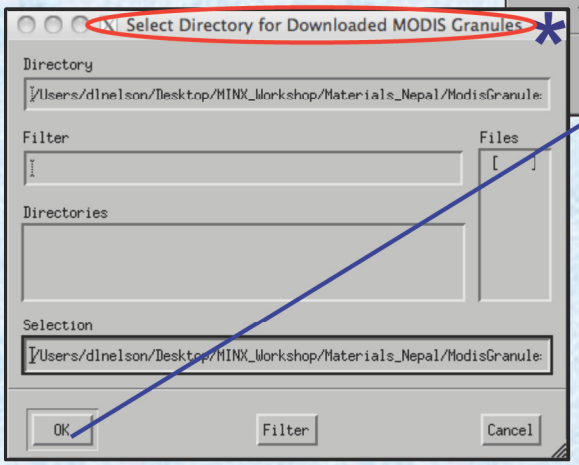
File is automatically read when "Process Plume Project" is selected from the main MINX menu

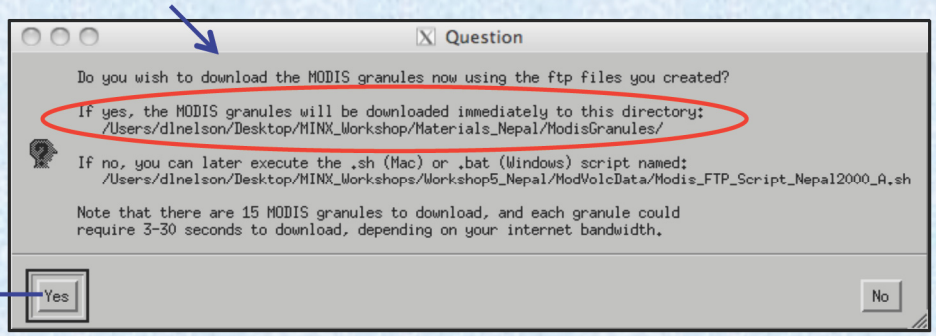
Plume Utilities – Process ModVolc Hot Spots - 6

If you selected "MODIS Fire Pixels" in the "Select ModVolc Parameters" dialog box, you will see these dialog boxes next

Select directory where MODIS granules will be downloaded and click "OK" to show results of filtering







See next slide

- The "Information" message box tells you how many fire pixels were filtered out and why
- Also how many MODIS granules need to be ordered
- The "Question" message box allows you to automatically download MODIS granules now - or use the saved ftp script file to download later

Plume Utilities – Process ModVolc Hot Spots - 7

Output Files from "Process MODIS Hot Spots"

MisrOrderList_Nepal2000.txt and MisrProcessList_Nepal2000.txt are created just as for "Process ModVolc Hot Spots"

Sample: FirePixels_01658_Nepal2000.txt

Fire pixels from MODIS granules on 275m MISR SOM grid for project : Nepal2000
1658 / 143 / 2000-04-10 : orbit / path / date

Longitude degrees	Latitude degrees	Blk	Samp 0-based	Line	Power MWatt	BTmpR2 reflec	BTmpT21 fire(k)	BTmpT31 fire(k)	BBTmpT21 bkgnd(k)	BBTmpT31 bkgnd(k)	Conf %
81.68207	29.00411	67	653	470	17.2	0.236	320.5	297.8	303.8	297.7	60
80.44640	28.95329	68	282	19	15.4	0.225	323.3	306.6	311.4	305.6	76
80.57449	28.90775	68	329	33	11.8	0.216	320.3	305.3	310.5	304.9	72
80.70905	28.85212	68	379	51	8.2	0.203	317.5	306.4	310.3	305.3	59
80.57658	28.86023	68	332	52	10.0	0.219	321.2	307.2	313.3	307.2	72
84.46432	28.28295	68	1732	140	16.5	0.188	314.8	295.7	298.6	293.9	41
80.91257	28.79835	68	453	66	16.4	0.222	324.9	305.8	311.8	305.6	47
80.85776	28.79649	68	433	69	8.9	0.205	320.1	308.3	312.7	306.9	44
80.45261	28.83216	68	289	67	8.8	0.241	321.8	308.3	315.1	308.5	74
84.24374	28.18143	68	1658	190	11.2	0.192	318.8	301.4	309.3	302.5	62
84.26181	28.15952	68	1666	198	9.6	0.199	316.6	303.5	308.1	301.9	42
84.35287	28.11608	68	1700	211	13.3	0.211	321.7	303.0	311.1	304.4	56
81.34144	28.49936	68	616	172	16.3	0.197	327.5	309.1	314.7	308.5	65

Fire pixel files now contain fire radiative power, brightness temperature and confidence metric

Sample on Mac: Modis_FTP_Script_Nepal2000.sh

```
ftp e4ftl01.cr.usgs.gov < "/Users/dlnelson/ModVolcData/ModisGranuleList_Nepal2000.txt"
```

Sample on PC: Modis_FTP_Script_Nepal2000.bat ???

```
ftp e4ftl01.cr.usgs.gov < "/Users/dlnelson/ModVolcData/ModisGranuleList_Nepal2000.txt"
```

Executing script Modis_FTP_Script_Nepal2000.sh from the MODIS granule directory will download the files listed in ModisGranuleList_Nepal2000.txt to that directory – MINX will do this automatically or you can do it manually

Sample: ModisGranuleList_Nepal2000.txt

```
anonymous

lcd "/Users/dlnelson/Desktop/"
binary
prompt
cd MOLT/MOD14.005/
cd 2000.04.10/
mget MOD14.A2000101.0530.005.*.hdf
cd ../2000.04.12/
mget MOD14.A2000103.0520.005.*.hdf
cd ../2000.05.10/
mget MOD14.A2000131.0545.005.*.hdf
cd ../2000.06.08/
mget MOD14.A2000160.0515.005.*.hdf
cd ../2000.06.11/
mget MOD14.A2000163.0545.005.*.hdf
cd ../2000.06.13/
mget MOD14.A2000165.0530.005.*.hdf
cd ../2000.06.20/
mget MOD14.A2000172.0535.005.*.hdf
bye
```

Plume Utilities – Process MODIS Fire Pixels - 1

If you selected "MODIS Fire Pixels" in the "Select ModVolc Parameters" dialog box, you will see these dialog boxes next

- Determine your project's geographic and date ranges
- Download all MODIS granules for your project as follows from website: http://reverb.echo.nasa.gov/reverb

① Go to website and register to download data if you haven't yet – "Sign In"
② Pan and zoom the map to center your project area
③ Select "Bounding Box", "Polygon" or other method and outline project area using the mouse
④ Enter MODIS MOD14 in "Search Terms" box
⑤ Check box by "MODIS/Terra Thermal Anomalies/Fire 5-Min L2 Swath 1km V005"
⑥ Specify starting and ending dates
⑦ Click "Search for Granules" button and wait for search to complete

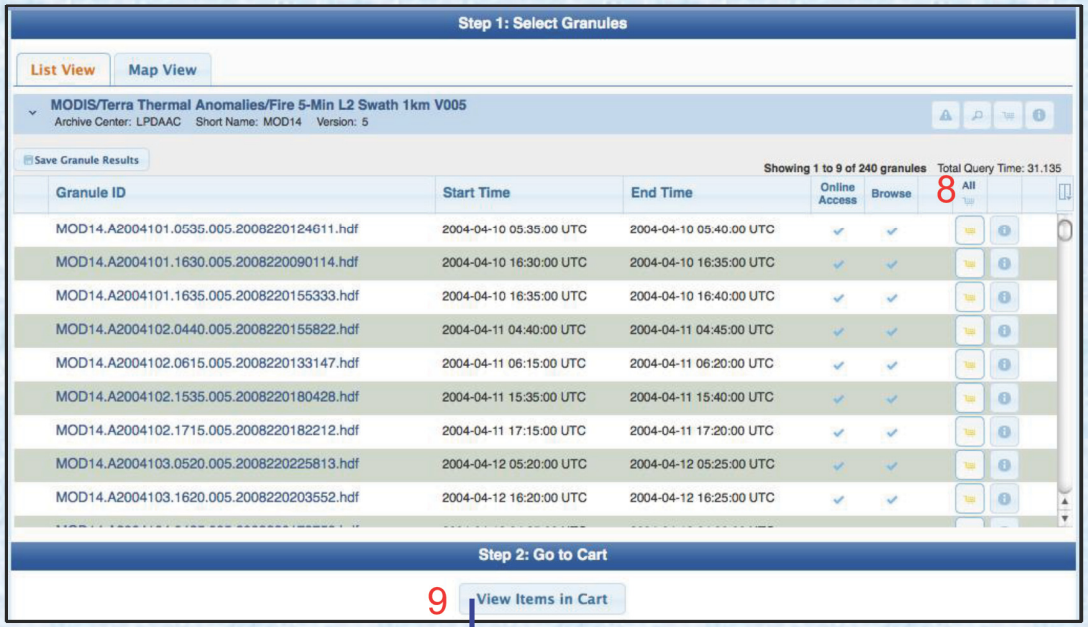
Plume Utilities – Process MODIS Fire Pixels - 2

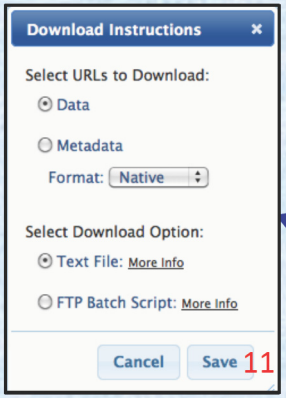
⑧ Click “All” above the cart symbol column to select all granules, and wait for search to complete

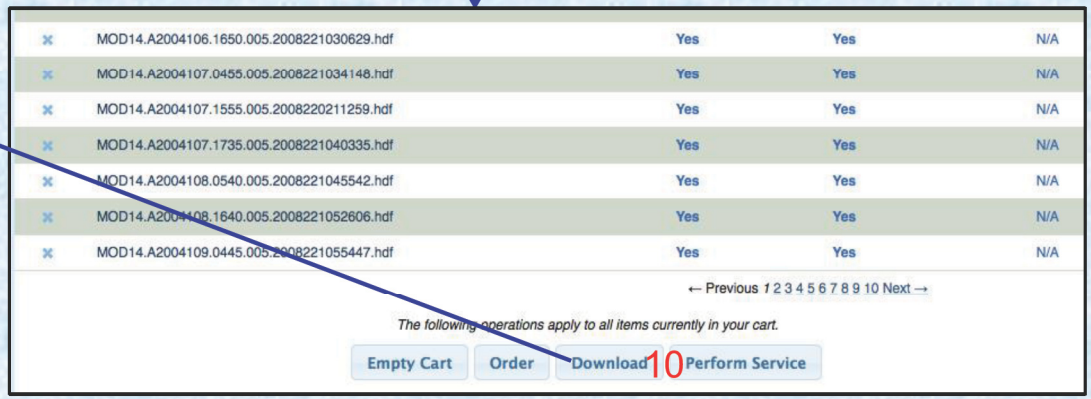
⑨ Click “View Items in Cart” button

⑩ When cart list appears, click “Download” button

⑪ On the “Download Instructions” dialog box, accept defaults and click “Save” – then accept file download







Each line of text in the downloaded file must look like this:

```
ftp://e4ftl01.cr.usgs.gov/MODIS_Dailies_C/MOLT/MOD14.005/2004.04.10/MOD14.A2004101.0535.005.2008220124611.hdf
```

Plume Utilities – Process MODIS Fire Pixels - 3

- Before your order is ready to pull, create a directory to contain MODIS granules
- When your order is ready to pick up:

On a MAC

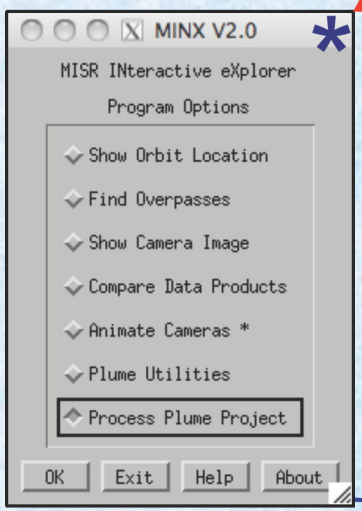
- Open a terminal window and change current directory (cd) to the new MODIS directory
- Enter these commands:
  - ftp e4ftl01.cr.usgs.gov
  - anonymous
  - <your email address>
  - wget –i <downloaded filename>

On a PC

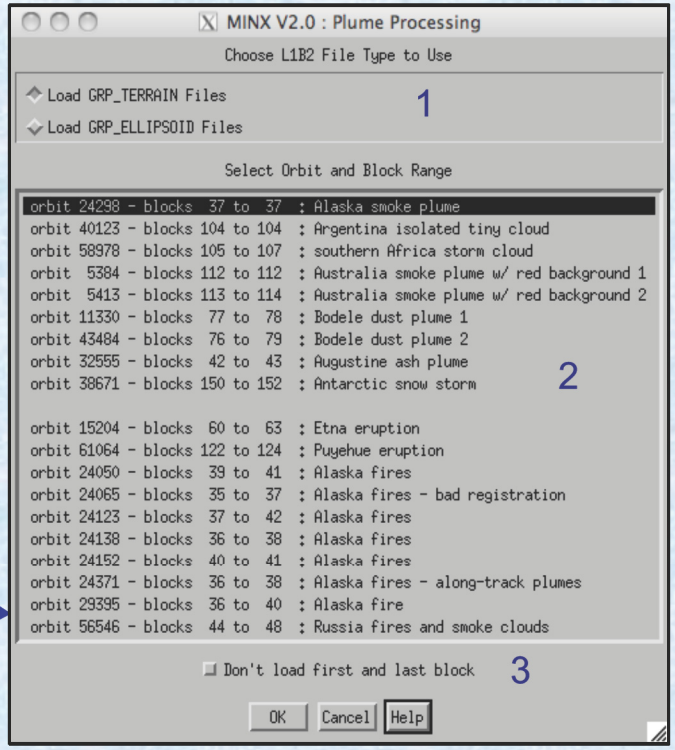
- In your browser Options, change the Downloads folder to the new MODIS directory
- Click the "Start" button, then "Run…"
- Type in "cmd" and press OK to create a command window
- In the command window enter these commands:
  - ftp e4ftl01.cr.usgs.gov
  - anonymous
  - <your email address>
  - wget –i <downloaded filename>

Process Plume Project - 1

Objective: To enable a plume digitizing project comprising many orbits to be processed rapidly by allowing a user to select orbits from a list and bypass multiple dialog boxes.



- Click "OK" and MINX searches for and reads a file with mandatory name "PlumeProjOrbitList.txt" and mandatory location home directory
- The file can be created using the "Plume Utilities" options (refer to slide Process ModVolc Hot Spots – 5) or can be hand-coded to contain a list of frequently used orbits/blocks
- If the file is not present or cannot be read, MINX will prompt user with the format to use to create file



1 Select the type of level 1 radiance imagery you want to load – always use Terrain data if the plume is over land – if over water, then it's OK to use Ellipsoid data

2 Highlight an entry from this list - when you click "OK", nine MISR camera images for the selected orbit and block range will be loaded and displayed without showing any other file selection dialogs

3 Checking "Don't load first and last block" instructs MINX to load the block range for the selected orbit minus the first and last blocks - useful to reduce the loading time when you want to quickly inspect an image

Process Plume Project - 2

- File PlumeProjOrbitList.txt must contain 3 lines of header plus a list of orbits to choose for processing. Do not create this file with an editor that inserts invisible formatting characters.
- The header must consist of 3 lines:
  1. One or two directory names where GRP_TERRAIN and GRP_ELLIPSOID files are located - use two names in the order above if you need to use both files types AND if they are stored in different locations - separate the names by at least one space character or tab
  2. Version string for GRP_TERRAIN and/or GRP_ELLIPSOID files (F03_0024 is latest as of 6/2012)
  3. Directory where MINX output data and images will be written
- Each successive line contains information for one orbit in this order in free format with items separated by space characters or tabs:
  - OrbitNumber BeginBlockNumber EndBlockNumber Comments
- The comments field may contain spaces and is optional - blank lines may be included in orbit list

```
/Users/dlnelson/MISRdata/GRP_TERRAIN  /Users/dlnelson/MISRdata/GRP_ELLIPSOID
F03_0024
/Users/dlnelson/00_MINX_output
 24298  37  37  Alaska smoke plume
 40123 104 104  Argentina isolated tiny cloud
 58978 105 107  southern Africa storm cloud
  5384 112 112  Australia smoke plume w/ red background
 43484  76  79  Bodele dust plume 2
 38671 150 152  Antarctic snow storm

 15204  60  63  Etna eruption over Mediterranean – use ellipsoid data
 32555  42  43  Augustine ash plume
 61064 122 124  Puyehue eruption
```

Sample hand-coded PlumeProjOrbitList.txt file

Recent Papers & Presentations Incorporating MINX Data

- Ekstrand, Angela - Geophysical Institute and Alaska Volcano Observatory, University of Alaska
  - "Application of MISR Data for Analyzing Volcanic Plumes in the North Pacific" – *AGU poster*, December, 2011.
  - "A Multi-sensor Plume Height Analysis of the 2009 Redoubt Eruption" – *Journal of Volcanology and Geothermal Research (submitted)*.
- Garay, Michael – MISR, JPL
  - "Dust Plumes in the Bodele Depression, Chad" - *presented at Fall AGU Meeting,* December, 2010.
  - "Volcanic Ash Clouds from Eyfjallajokull Volcano, Iceland" - paper *in preparation for JGR.*
  - "Volcanic Ash Clouds from Puyehue-Cordon Caulle Volcano in Chile (summer student project)" – paper *in preparation*.
  - "MINX Plume Height Validation with Ground-Based Lidar (summer student project)" - paper *in preparation*.
- Kahn, Ralph - NASA Goddard Space Flight Center
  - "Wildfire Smoke Emissions – What we learned from MISR and MODIS." invited talk @ 34th International Symposium for Remote Sensing of Environment (ISRSE), Sydney, Australia, April, 2011.
  - "What We've Learned from ~12 years of MISR Aerosol Observations." invited talk @ Workshop on observations and modeling of aerosol and cloud properties for climate studies. Paris, France, September, 2011.
  - "Aerosol Constraints from Multi-angle Imaging That Modelers Can Use." AeroCom annual meeting, Fukuoka, Japan, October, 2011.
- Kalishnikova, Olga – MISR, JPL
  - "Dust Plumes in the Taklamakan and Gobi Deserts in China" – presented at *Fall AGU Meeting*, December, 2011.
- Scolla, Simona - Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo, Italy
  - "MISR Observations Of Etna Volcanic Plumes", submitted to *Journal of Geophysical Research – Atmospheres*, November, 2011.
  - "Three-dimensional volcanic aerosol dispersal: A comparison between Multiangle Imaging Spectroradiometer (MISR) data and numerical simulations" – published in *Journal of Geophysical Research*, December, 2010.
- Tosca, Mike – Department of Earth Sciences, UC Irvine
  - "Dynamics of Fire Plumes and Smoke Clouds Associated with Peat and Deforestation Fires in Indonesia", published in *Journal of Geophysical Research* – April, 2011.
- Val Martin, Maria – School of Engineering and Applied Sciences, Harvard
  - "Smoke Injection Heights from Fires in North America: Analysis of five years of Satellite Data", published in *Atmospheric Chemistry and Physics*, February, 2010.
- Wu, Dong – NASA Goddard Space Flight Center
  - "Inner-Core Dynamics of Hurricane Alberto (2000) as Observed by MISR and MODIS", paper *in preparation*.
  - "Use of MISR Stereoscopic and MODIS Infrared Techniques to Observe Small-Scale Dynamics of Cloudy Boundary Layer", paper *in preparation*.
  - "MISR CMVs and Multiangular Views of Tropical Cyclone Inner-Core Dynamics", published for *10th International Winds Workshop, Tokyo*, Feb, 2010.

Smoke plumes	Dust plume	Volcanic plumes	Clouds	General